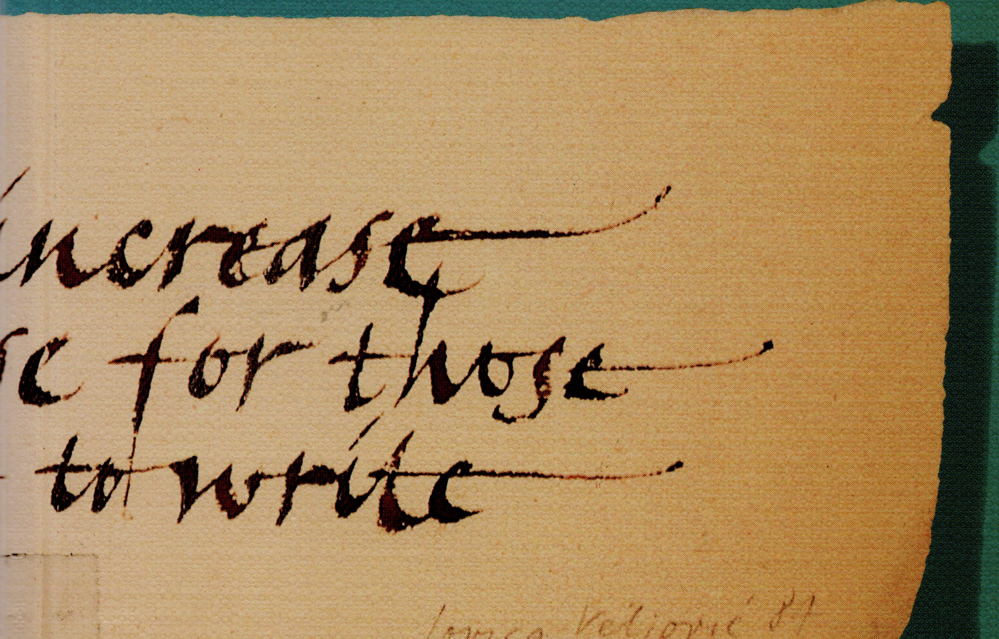
Digital Formats for Typefaces

Peter Karow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Digital Formats for Typefaces

by Peter Karow

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Summary

This book is intended to be mainly of interest to all those people who intend or wish to develop new machines for the output of typefaces.

It is possible to distinguish between three groups of equipment for which digital alphabets are required – display devices, typesetting machines and NC machines. Up to now the development of typefaces has been too dependent upon the design of the respective machine used. This needs not be the case. The digitization of type should be undertaken in two steps: firstly, the preparation of a data base using hand-digitization, and subsequently the automatic generation of machine formats using soft-scanning, achieved through the use of computer-based programs.

The digital formats for typefaces are suited to systematic ordering, as are the coding techniques. The various formats are investigated, their properties discussed and the relative production requirements analyzed. The appendices provide the reader with additional information, mainly on the digital formats for typeface storage as introduced by the IKARUS System.

This book is set in Marconi. Marconi was designed by Hermann Zapf in 1976 and prepared, by Peter Käpernick, for typesetting on Dr. Ing. Rudolf Hell Company's Digiset machine in 1976/1977. Marconi is the first typeface prepared for electronic typesetting with the aid of the IKARUS system.

Preface

This book is aimed at both technicians in electronics, and users of typefaces in many and varied applications. It is more than just an introductory book; it touches on a whole series of areas involving the digital preparation of typefaces.

In the past, typefaces used in visual display terminals (VDT) were often developed by engineers. Not only did the level of technology at the time place limits on the creation of good letterforms, but also the joy of experimentation was sometimes a predominant factor in the creation of type using electronic media. The aesthetic consideration of the letters was secondary.

Many of the current digitally generated types are difficult to read, some ignoring all the basic rules of legibility. We should not forget that legibility is not an outmoded term. Our eyes and reading habits – leaving out OCR information for the moment – have not changed over the centuries.

Consider for example the type used in modern video communication systems or on TV transmissions. The word images, sometimes using unusual typefaces, and shown for only short periods on the screen, are often difficult for the average, quite apart from the aged, viewer to distinguish. The letters are usually too closely spaced, and the word images often blend into one another representing an additional handicap for the frustrated reader. If a sans-serif type is used and the r and n are too closely spaced an m may result; the letter c and an l too closely spaced may unintentionally produce the letter d and so on.

This tight typesetting is a product of fashionable thinking in advertising which often leads to the formation of word images with letters too closely spaced. Each reduction of the letter spacing in texts also leads to an inevitable loss of legibility. We should not forget that the rapid recognition of word images is the primary task of all type character reproduction.

The legibility of many visual display terminals could be appreciably improved if the lines were set slightly further apart and the letter spacing were allowed to revert to a normal constant.

In the days of hot metal composition it was normally impossible to print letters closer together. Only with the arrival of phototypesetting with its new possibilities did letter spacing reduce, and obtain the bad habits it has now.

Writing is the visual reproduction of the spoken word, its primary objective being to convey a text to the reader without difficulties, immediately, and without disturbing the flow of reading with unnecessary embellishments.

The letters have no self-fulfilling purpose, neither are they a medium for self-representation. Their most important task is to provide clear differentiation between individual characters. This applies not only to the letters. Bearing in mind the importance of numbers in a modern industrial society, consider how easily the numerals 3, 6 and 9 can be mistaken for the 8. In telephone directories – especially if printed black on white – it can rapidly become a problem to distinguish between these individual numerals in the very small type sizes used. This leads us to one of the important criteria for new types: clearly distinguishable and unmistakeable forms.

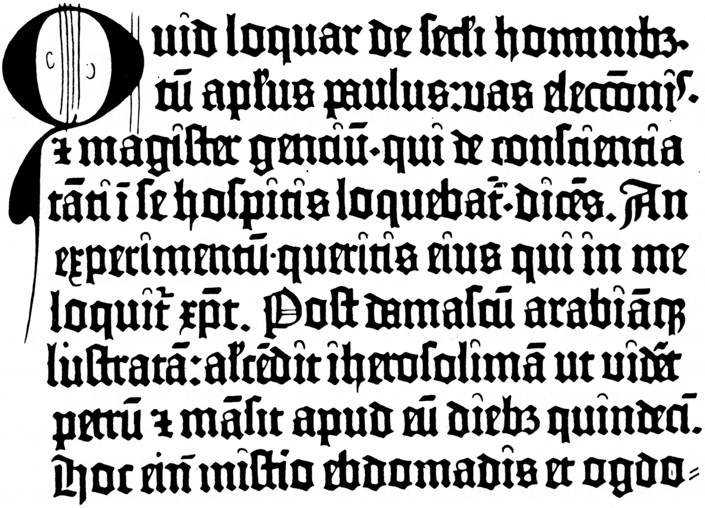
Everything which makes reading more difficult or lengthy, or is detrimental because of its unusual form, has to be avoided. When considering a typeface all of these factors have to be included right from the start. The drawing of letter forms should also be able to meet aesthetic requirements. Each eccentric character within a word image disturbs the reading flow, and therefore the rapid comprehension of the text.

This handbook from URW is intended to provide an introduction to the many problems of typeface creation and digital typeface preparation. Not everything to do with typefaces is rational and logical. There are many purely optical factors to be considered. They are the result of long development throughout the history of type, based on experience and knowledge, which should not be ignored.

The primary objective is not to produce incredibly attractive, artistic alphabets as in the past. The application and development of new alphabets, as approached in this book, require the optimum utilization of the technical possibilities available today, and those future methods of type reproduction already hinted at.

Our current task is not to copy old typefaces, e.g. Garamond Antiqua from the 16th century or a Bodoni from the 18th century. We now live in the era of technology and electronics. We should try and solve our current problems by contemporary methods.

Many early type fonts stemming from the centuries following Johannes Gutenberg were designed for printing on wooden hand presses and predampened paper. The technical possibilities of type composition – with all its limitations – also determined the form of the letters.



Quid loquar de ſecli hominibꝫ.
cū apſ̄us paulus:vas elecōniſ.
⁊ magiſter gentiū·qui de conſciētia
tāti ī ſe hoſpitis loquebat̄·dicēs. An
experimentū·queritis eius qui in me
loquit̄ xp̄c. Poſt damaſcū arabiāq;
luſtratā:aſcēdit iheroſolimā ut videt
petrū ⁊ māſit apud eū diebꝫ quindecī.
Hoc enī miſtio ebdomadis et ogdo=

Text from Gutenberg's Bible

The infinite possibilities provided by today's electronics should be used to develop types of our time, without historical hangovers. Clear forms, but not cold or machine-like in appearance, which can lead to an unconscious rejection by the reader and an unwillingness to read longer texts.

In addition, we are currently at the start of an era of new developments in the digital application of type characters. Whereas previously we were satisfied if the lines were just legible on the VDT, the current trend of development is to produce innumerable variations from stored basic fonts with high legibility.

Typography has previously been limited to two dimensions. The future technology will take letters and produce three dimensional effects and images with perspective distortion.

URW's experience in the area of type generation with the IKARUS system now covers a period of more than 10 years. Peter Karow was able, using the IKARUS system, to develop a new method in a program for the mathematical classification of type characters with high aesthetic qualities for the first time. The multitude of possibilities provided by modification and interpolation led to new ways of developing whole type families. The results will benefit today's users.

The computer aided mathematical conversion of letter forms will soon lead to a creative process with which it will be possible to generate more and more new and attractive solutions using letters and single word images. The IKARUS system represents the start of a new era in the reproduction of type characters. It will also make its presence felt as new areas of application demand aesthetically pleasing types.

A font, stored on a chip and having high digital precision and quality of shape will then help us to convert the many, often primitive, type characters currently on our display screens and computer printouts into pleasant types, using fonts to which we have become accustomed over the centuries in the standards of the Gutenberg art of printing. The quality which was once taken for granted should also be the standard of the future in the digital field.

Hermann Zapf

1. Introduction

The invention of electronically controlled machines for text display and output led to the digital storage of type. These machines can be divided into three groups according to their usage:
- Visual display devices (VDT, graphic VDT, TV)
- Typesetting machines (CRT, laser, microfilm, matrix)
- NC machines (drawing, cutting, routing, engraving).

Visual display equipment is used for the rapid display of texts on TV monitors. As a rule this purely electronic display for a temporary and cost-effective presentation has led to the development of bad letter quality, not aiding legibility. Not particularly beneficial to mankind!

Typesetting machines create text on film, printing plates or paper which are of more permanence and often only to be read at some later date. The presentation of the letters is usually of a very high quality, excluding for the moment the dot-matrix printers used in data processing.

NC machines are used for drawing on paper, for cutting self adhesive materials, for cutting, routing or engraving wood, metal or plastic. In this field the quality can be sometimes very poor (for example, the letters produced by character generators in plotters), which is unforgivable, but also extremely high (e.g. on flat bed drawing machines cutting materials for display on hoardings, windows, vehicles etc.).

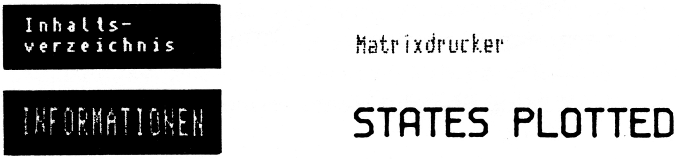
In the course of using digitally stored types we have discovered the following:
- The developments within these three groups are independent of each other. No one knows what the others are doing.
- Typesetting machine manufacturers have made great efforts to achieve high quality.
- No one has as yet attempted to integrate the work of the separate fields to produce type with good legibility and reproduction quality on the various electronically controlled equipment.

In addition one must recognize that most development engineers associate type with Latin, Arabic or Chinese symbols for the reproduction of words. But there is much more involved: it is the reproduction of whole messages (advertisements, signs, books, newspapers, journals, tables, plans, calculations, drawings). Thus, in addition to letter types one needs to be able to represent logos, symbols, vignettes, frames or line graphics, or elements for the generation of line graphics.

Note: Within the terms of this discussion, type is used to denote all elements necessary to reproduce a message within the framework of electronic communication, be it on the visual display unit, on paper or any other material!

Returning to the consideration of the equipment:

it is a fact that its developers are usually engineers who, working under the pressure of time, have to produce the next improvement of their machine, to make it cheaper, faster or more powerful. Hardly anyone gives any thought under such conditions to improving the reproduction of type. And yet it is so obvious; because all of these devices use type for communicating with people. It appears as if the engineers have extrapolated from their own handwriting, since it has generally been adequate for communication in the typing pool or in the private sphere: someone has always been around who could read it. So they assume that computer type doesn't need any beautification or further treatment.



Examples of poor quality

As a consequence, letters are considered to be a necessary evil and are prepared for digital storage with the minimum of time and financial expenditure.

Two examples make this behaviour clearer. One of the inventors of the electronic typesetting machines has said what amounts to the following on the matter of type: “We have now finished the development of the typesetting device, there are scanners included in our supply program. So, our customers are getting a CRT typesetter with a scanner and should then be able to produce their own type." In the twenty years since then virtually none of the users has achieved this.

A similar reaction was given recently by one of the developers of alphanumeric VDTs with proportional type. He had taken approximately two years to develop the hardware and software, and approximately three hours of this for the actual proportional type to be displayed. He literally added: "The type was really no problem," this was reflected in its quality. And by the way, for this developer there was only "the type". He obviously makes two classifications of type species:

Handwriting and computer type.

Let us hope that in future the producers of writing machines place more emphasis on the quality and variety of the reproduction of type!

Further consideration of the three most important areas of application of type in connection with computers and electronic control will lead the observer to conclude that all devices have the following properties:

- Type is always stored in such a way that its digital form can be converted as directly as possible into electric signals, and
- on the whole it is not possible for type to be loaded into the writing machine by the host computer.

This last point can usually only be resolved if all system components for an application are supplied by the same manufacturer.

These two characteristics can have disadvantages. Within the scope of a particular machine the type has a specific digital machine format plus a specific face. All developments show that the generation of digital formats always proceeds within the scope of this one machine, to be introduced into the market as soon as possible. No one has looked further than the production and completion of this one machine and no one has considered that in any dynamic company, the product of today is followed by tomorrow's development of the next machine. So, type has always been developed, digitized, corrected and stored within the narrow limits of specific formats. This is an expensive habit! Every subsequent machine then requires the repeated procedure of digitization, correction and storage of type – because as a rule one machine's format is not convertible to that of another machine unless one has used the same raster resolution in order to achieve the same type size.

This is also the reason for one of the bigger disadvantages of writing machines. Each particular machine has its own particular machine format, which as a rule can only be properly handled by the manufacturer. If a user of one of these machines wishes to run products from another manufacturer, a change of type is often unavoidable, i.e. a change of type format and the specific type appearance, and in some cases even the type font itself.

These disadvantages can be overcome by the following procedure: the digitization of type is carried out independently of any specific machine. This digitization has to be universal so that it can be adapted to any desired application. To put it another way: all machine formats are calculated by computer from one mother format.

The machine formats will be standardized and made accessible to all developers the world over. Manufacturers would be very happy about this – type would no longer represent a problem. Similarly, users would also be pleased; they could change setting machines without having to adjust or adapt to the new type font specific to the new machine.

In order to show how this objective can be achieved this book includes a detailed description and investigation of the various equipment classifications, several machine formats worth mentioning, coding techniques and finally the demands and problems imposed on type data formats by typesetting.

Subsequently, the properties of digital formats for type are illustrated and requirements developed for these formats.

In the final chapter, conclusions are drawn and suggestions made for the future course of progress in the manufacture of type data. Throughout this the reader should keep a critical eye on the quality of the text reproduction, which need not be neglected when using digital storage.

2. Typeface terminology

First the reader should be introduced to special expressions and terms used in the typeface world.

First of all, we shall consider the standard appearance of letters in normal print, black on white paper, i.e. letters physically present, and not stored digitally on some electronic or magnetic storage media, thereby no longer directly visible, but abstract. We are dealing here with terminology as used in the world of type designers and type producers.

Types are divided into two main groups: text and display.

The first refers to types used for the body of a text material in newspapers or books, the other is for titles and headlines.

Each type has its own special character and style. Currently, there are probably more than 10,000 different Latin typefaces available.

A simplified classification – following ATYPI [Association Typographique Internationale] guidelines – may be carried out as follows [see also appendix A]:

Class	Typeface
Roman [Antiqua]	Baskerville **Bodoni** Garamond Palatino Times Optima
Sans serif [Grotesk]	**Futura** Helvetica
Black letter [Textura]	Walbaum Fraktur
Script, Cursive	*Ariston*
Fancy, Free	**Goudy Fancy**

Many types are available in different fonts (complete assortments of characters of one size and style). These typefonts are also known as the type family. Such a family often consists of four upright and four italic type versions (differently weighted fonts).

ITC (International Typeface Corporation in New York) produces four families a year according to this scheme, i.e. 32 different versions or fonts. ITC is one of the most active companies in the world developing new typefaces. The slanting angle of italics (slope to the right) is usually 12 or 12.5, rarely 15 degrees. The weight designations are as follows:

light	(mager)
medium	(normal)
demi	(halbfett)
bold	(fett)

A member of a typeface family is properly identified if one says for example “Optima demi italic”. Previously, the type sizes were produced individually in hot metal composition and then set. There is no reason why these particular forms should not be retained, even in the age of digital type: we shall therefore continue with the concept as before, whereby from one font special versions were made in the various sizes of 6pt, 8pt, 9pt, 10pt, 12pt, 16pt, 18pt, 24pt, and 36pt (where pt = point).

First of all we can identify the individual letters using well known denotations. These are the letters “A” to “Z”, the numerals, the punctuation marks (i.e. comma, full stop, question mark etc.) and language variations (e.g. ä, ö, ü, œ and ø). The marks over the letters are known as accents. Other accents are also available, e.g. ´ and ˆ for both upper and lower case letters. Currency symbols are also available, e.g. £ and $. Large letters are known as capital letters, caps, upper case. The small letters are known as lower case or minuscules. When capital letters are as small as the lower case letters they are known as small caps. And that isn’t all.

Type experts have even more possibilities, there can be characters which are “raised” and “lowered”, e.g. ^{0} or $_0$. The elevated characters are known as indices, superiors, superscripts or exponents, the lower are known as indices, inferiors or subscripts. Using both together one can produce fractions, e.g. ¼ or $\frac{1}{4}$.

Most European languages require the use of accents to allow proper reproduction. This is very important. Only English no longer uses accents. Accents and special signs are a fairly large group, e.g. in

Czechoslovakian: ÁáČčĎďÉéĚěÍíŇňÓóŘřŠšŤťÚúŮůÝýŽž
French: ÀàÂâÇçÉéÈèÊêËêÎîÏïÔôÙùÛûÜüÆæŒœ
German: ÄäÖöÜüß
Polish: ĄąĆćĘęŁłŃńÓóŚśŻżŹź
Spanish: ÁáÉéÍíÑñÓóÚúÜü
Swedish: ÅåÄäÉéÖö

In appendix B you will find a summary of the letters in a Latin typeface with their designations, and in appendix C we have gathered together the accents for Latin letters. In order to gain an overall view we have included, not comprehensively or with pedantic accuracy, a few more terms worth knowing.

There are signs for formulae in mathematics, e.g. the root sign $\sqrt{}$ or the integral sign $\int$. Mathematics cannot, in fact, get by using only Latin letters, mathematical type includes Greek letters and Black letters among it’s variants.

The type family AMS-Euler, a type for the setting of mathematics, was developed by Hermann Zapf in the Metafont system (see also chapter 5.2) together with Donald Knuth for the American Mathematical Society and Stanford University, and covers around 900 characters.

Other special typesetting elements:

Newspapers need a whole range of various line elements for producing line borders. Advertisement creation requires elements for embellishment and decoration. At this stage we have already moved away from type characters proper. In addition, special types (e.g. so called Pi-fonts) are also required, which consist of decorative or swash elements or of ornamentation and special characters, and serve to hold the reader's attention. In appendix D we have included the "Dingbats" series from ITC, as designed by Hermann Zapf.

Ornamentation elements are also referred to as vignettes or embellishments, whereas a more pictorial representation, e.g. a tree, may be called a line graphic. Letters can also be reproduced as half tone or patterned. The letters – or rather their outlines – are filled with grey tone or grids of hatching or dots.

Before this text becomes too uninteresting for technicians, for whom this book of digital formats is mainly intended, we shall concentrate on individual letters and the formation of words.

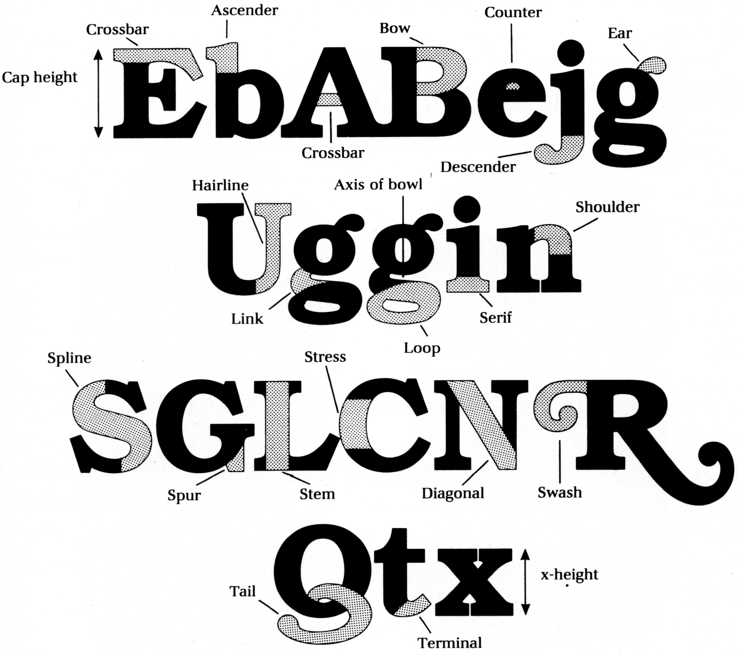
In antiquity, letters were chiselled in stone or inscribed in clay (e.g. the Sumearian cuneiform). Letters were scratched, or written with a feather stylus (quill) and, in the western world after the middle of the 15th century, also appeared in printed form (Gutenberg in Mainz, Germany). All such letters have a certain thickness of stroke, for example the width of the basic stem of an "I". At the top and bottom this capital I has serifs. The "D" has one straight and one curved basic stroke, this can also be described as one straight stem and one curved stem. The lower case "n" has no ascender or descender, whereas the "h" has an ascender and the "p" a descender. The white inner spaces of lower case letters such as "o" or "n" are sometimes known as counters.

The "n" has an upper white "ink trap" where the second, initially curved stroke leaves the first straight stroke.

The "O" is approximately 1.5% higher than the "H", which is why it has an upper overhang. It also overhangs the base line (body line, type line), a base overhang. Curved lines have to be made larger in order to appear optically "of the same height".

The "H" has two vertical stems and one horizontal crossbar. These strokes appear to the reader to be of approximately equal thickness if the horizontal stroke has approximately 85% of the thickness of the two vertical strokes or stems, with respect to sans serif forms.

But not to worry, this book is not intended as a course in typography. However, technicians and programmers in the fields of typesetting machines and letters do require some knowledge of a few basic items. There are various books available (see appendix Z).

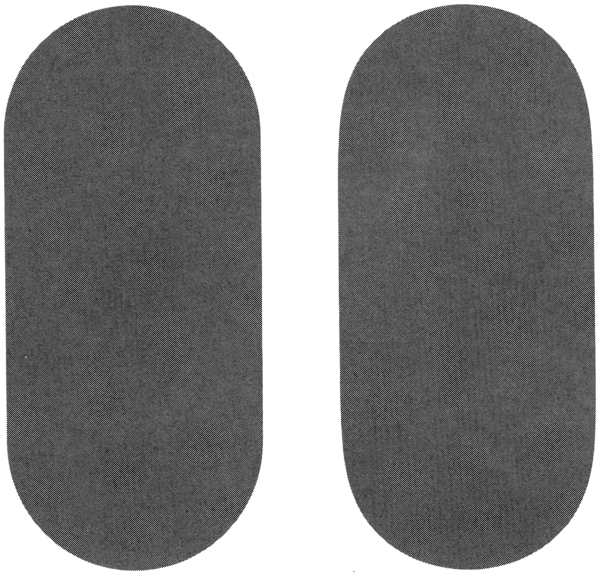

Ascender
Crossbar
Bow
Counter
Ear
Cap height
Crossbar
Descender
Hairline
Axis of bowl
Shoulder
Link
Serif
Loop
Spline
Stress
Spur
Stem
Diagonal
Swash
Tail
x-height
Terminal

Special expressions used for parts of characters.

The transitions from straights to curves (e.g. in "m") are known as tangentials. Such transitions are optically more effective if one sets a clothoid on the straight. A clothoid is a type of spiral with a curvature starting at zero and increasing along the curve.

Motorway exits are often clothoid in design: when coming from the straight, one wishes to enter the curve without having to wrench on the steering. The turn of the steering wheel is a measure for the curvature of the carriageway. The same applies to the optical effect of tangential transitions in letters and logotypes. They too should be clothoid.

It is immediately noticeable if one takes a standing rectangle and places a semicircle above and below. One generates something which looks more like a bone than a rounded stem.

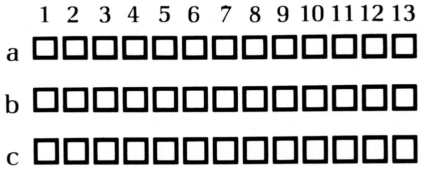


With semicircles added

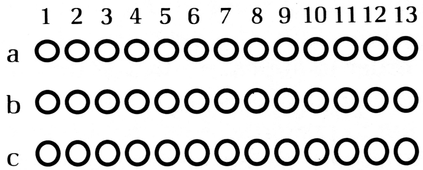
With clothoid curves

The above mentioned optical effects would seem to me to be related to optical illusions. It is a well known fact that when recognizing or comparing forms and figures, mistakes of recognition occur.
As a small exercise we would like to confront the reader with a few basic questions.

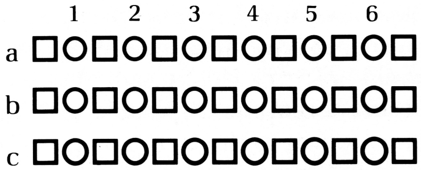
1. Which rectangle appears to be a square? Please cross.


1 2 3 4 5 6 7 8 9 10 11 12 13
a
b
c

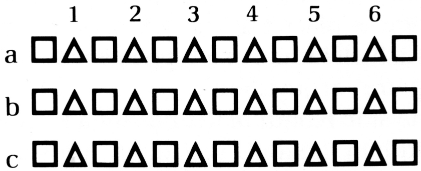
2. Which ellipse appears to be a circle? Please cross.


1 2 3 4 5 6 7 8 9 10 11 12 13
a
b
c

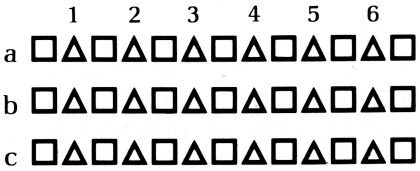
3. Which circle appears to be as high as the squares? Please cross.



4. Which triangle appears to be as wide as the squares? Please cross.



5. Which triangle appears to be as high as the squares? Please cross.



We have compiled our explanations and details of optical effects in appendix E. They are based on statistical averages as a result of an investigation involving 130 test candidates at URW in Hamburg.

In summarizing, we can say that a square only appears to be a square when it is 1% higher than it is wide, the same applies to circles. Furthermore, circles (curves) first appear as large as squares when their diameter is 3% greater than the length of the square (straight capital letters).

In the case of triangles (e.g. letters A and V) the height should be 3% and the width 5% greater than the corresponding square side length in order to appear as high as they are wide.

These percentages are mean values. The whole aim of this exercise is not to prescribe how one produces optically satisfying effects. We are merely trying to provide guidelines. Each particular typeface has, as might well be expected, its own individual effects and its own individual "excesses".

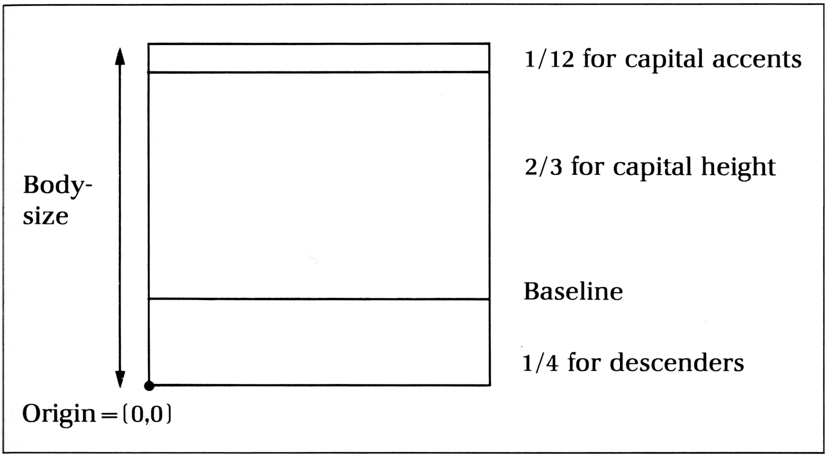
These and other optical effects can only be properly and correctly considered by experienced type designers. In future all technicians should bear this fact in mind. Let us hope that we have seen the last of those "computer typefaces in 3 hours".

Let us return to the terminology of letters. Some terms are from the era of hot metal composition.

A digitally stored letter has a mathematical reference point. In geometry this is known as the coordinate zero point, or the origin. This point is placed at the left hand lower corner of a squared box, into which all letters of a typeface will fit. This square is known as the "em square" or just "em".

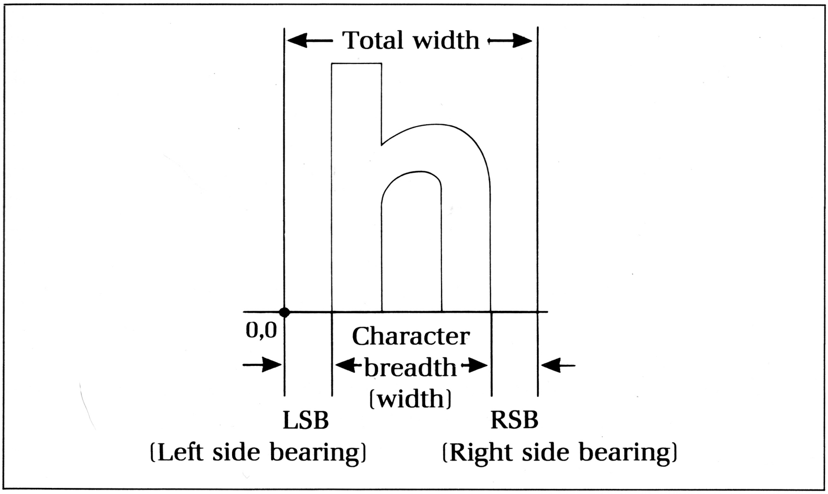
The side length of the em square should be equal to the largest letter width in the font. The letter "m" is quite often the widest letter and is possibly the origin of the term "m square(d)". The height of the em is known as the "bodysize". The breadth of the letters is known as the width (measured in digital units), which is often relatively small for the letters "i" or "l" and often equal to bodysize in the case of "m" or "W".

The bodysize must also be large enough for accents, ascenders and descenders. The following is a commonly used division:



Body-size
1/12 for capital accents
2/3 for capital height
Baseline
1/4 for descenders
Origin = (0,0)

Later in this book, in section 8.2, we propose a new em square, not to irritate friends, but rather to make life easier in the future.
Letters themselves rarely take up their total width, they have a left side bearing and a right side bearing (the white spaces on the left and right of the letter).



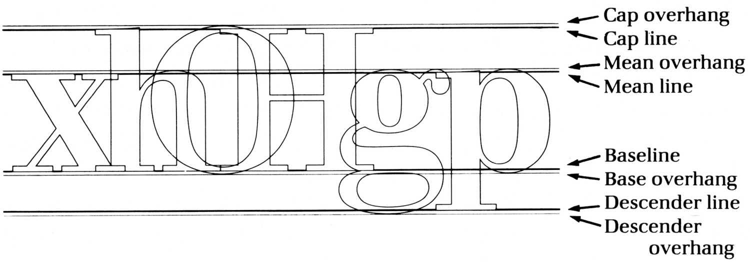
Total width
0,0
Character breadth (width)
LSB
(Left side bearing)
RSB
(Right side bearing)

The left and right side bearings are intended to allow the letter to appear optically balanced next to any other member of its typeface. In practice this is of course a compromise, because the spacing between letters is dependent upon the form of the preceding and following characters. Consider for example the A and two possible following neighbours B and T.

In hot metal composition we would have the following images, AB and AT. In the case of "AT" the T could be brought closer to the A, because the "A" is wider at the bottom and the "T" is wider at the top. In metal composition this is no simple matter, since the intervening metal has to be removed mechanically by hand. This is known as kerning (undercutting). Only then does "AT" appear as optically balanced as "AB".

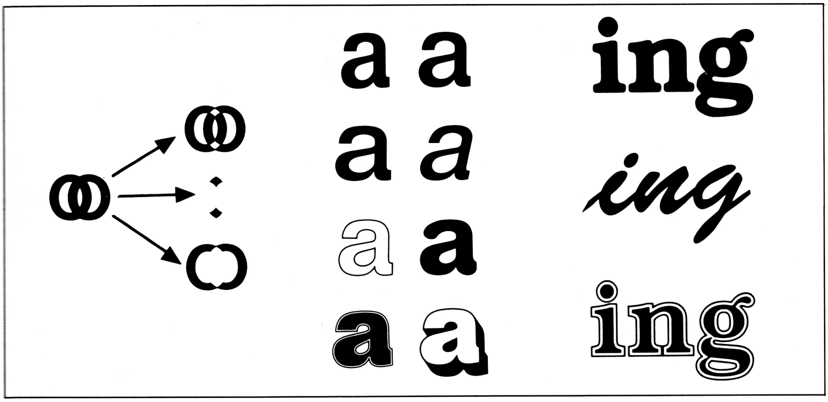
Where groups of letters are combined, as for example ff, fi, fl, ffi, ffl, we have what are known as ligatures. They are combined and used as one character. Some examples of ligatures with hardly recognizable characters are the German ss – ß (ſs) and et – & (&).

Subsidiary lines also run parallel to the baseline, as shown in the following diagram:



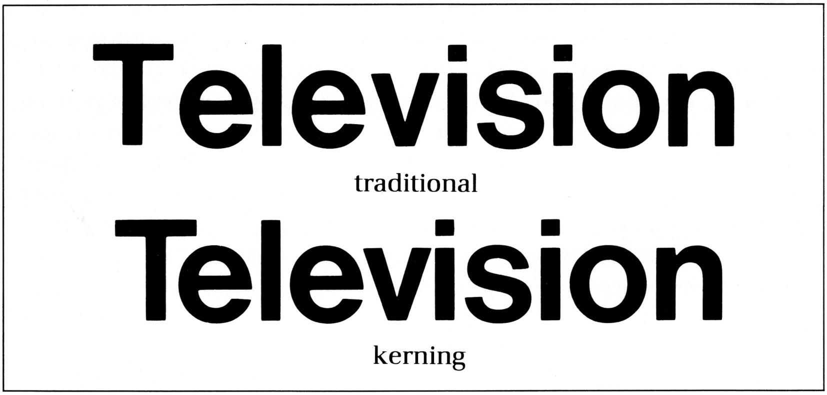
The thick lines are more important than the thin ones. The relative position of the thin to the thicker lines varies from face to face. There are no exact guidelines because their position depends on the type design. Digital storage for coarse resolutions sometimes requires a more rigidly specified positioning of the auxiliary lines than that required in the original typeface, which does not help to improve its appearance.

Typefaces may be modified, given an italic angle, expanded or condensed. The characters can be contoured, "antiqued" (artificially aged) or rounded. One may change the lower case height in relation to the cap height, blend whole words together, or give letters various shading, and in general create entirely new letter forms.

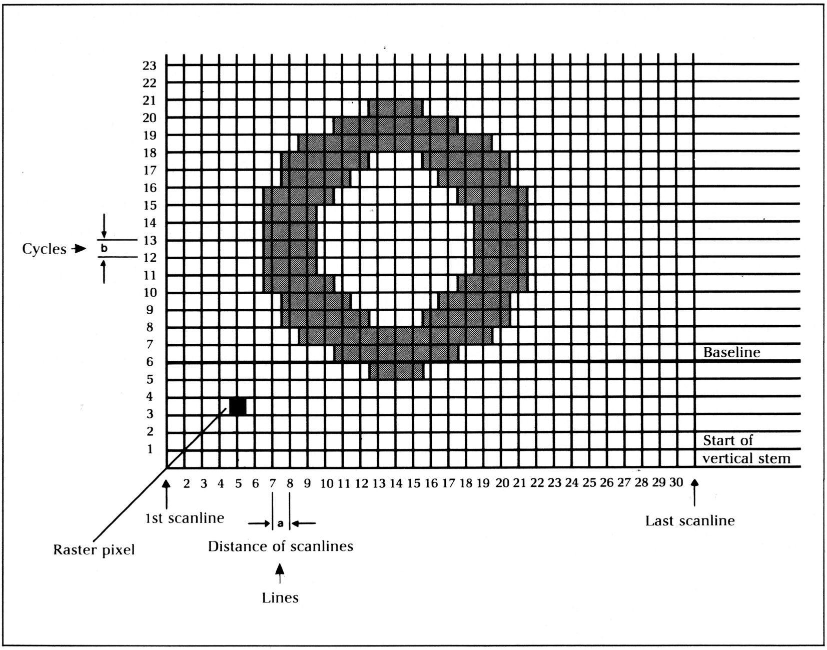


Using simple geometric operations they may be enlarged, condensed, rotated and distorted. Envisaging transformations like these is undoubtedly no problem for technicians. On the other hand, there is a whole series of devices which are incapable of doing this at all, for example most VDTs.

Nowadays most VDTs set " MONOSPACED ", i.e. all letters have the same set width. This is also termed "non-proportional". Typesetting machines set with proportional widths, which is a very great advantage. Setting can be further improved when not only the right side bearing is adjusted to the left side bearing of the next letter, but the space between any two letters is also adjusted specifically for that pair of letters, i.e. using the technique of digital kerning. Consider for instance:


Television
traditional
Television
kerning

Finally we have a few special terms associated with the digitization of type. All devices write with a certain line resolution, which is


23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Cycles
b
Baseline
Start of vertical stem
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
1st scanline
a
Last scanline
Raster pixel
Distance of scanlines
Lines

specified in either lines per inch or lines per millimeter. This means that the black faces of the letters are generated by the machine (e.g. typesetting machine) so that black lines of a certain thickness are drawn, line by line. A further limitation of digital technology is the line itself; the writing line can only be switched on or off in certain, electronically specified periods (cycles). This means that white or black sections of a line consist of a number of beats (pixels). The letters then appear as lines and dots on a horizontal and vertical raster (or grid). One talks of a 400 × 400 raster where the em square consists of 400 scanlines and 400 pixels per line in both the X and the Y direction. One may also describe this as an em with a 400 × 400 raster resolution.

We are of the opinion that describing a letter according to its em is the best way of picturing the digitization of type.

One Didot point = 1p is the generally accepted unit of measuring for type size. Previously, according to Didot 62 2/3 points = 23.566 mm. However, in Europe nowadays one normally works with the new Didot point and the dimensions 1p = 0.375 mm, whereas in America it is standard practice to use the pica point where 1pt = 0.351 mm. One inch (1 inch = 25.4 mm) has approximately 72 pts (more precisely: 1 inch = 72.27 pts).

Legislators would like to see a new dimensioning of capital letter heights (H-height) in mm, rather than bodysizes in points. At the moment typesetting machine manufacturers give measurements in both systems; the world of printing is very conservative, and the old units are often still in use.

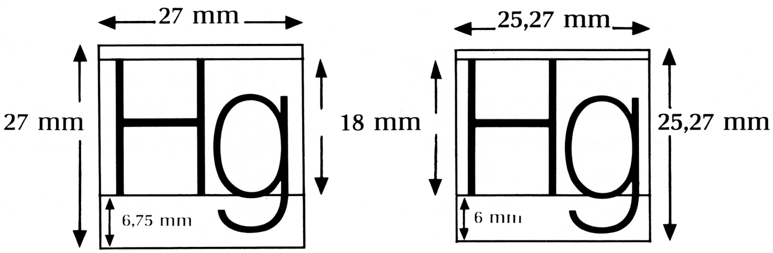
Texts in newspapers usually appear in 9p ≅ 3.4 mm bodysize ≅ 2.25 mm cap height, 10p is also sometimes used.

Typewriters often have 9.5p ≅ 3.6 mm bodysize ≅ 2.4 mm cap height, others have 10pt = 3.51 mm bodysize.

If we consider the 9p em as standard size then we have:

Writing resolution in		Raster for the 9p em
l/mm	l/inch	
7	180	24 × 24
9.4	240	32 × 32
11.8	300	39 × 39
15.7	400	54 × 54
32	813	108 × 108
64	1626	216 × 216
96	2438	324 × 324

If we place a 9p Didot em next to a 9pt pica em, both with eightfold magnification, one can recognize a difference in bodysize of approximately 7%, **but an H-height almost the same.** The pica em of most companies allows less room for descenders.



72p Didot em	72pt Pica em

As the bodysize determines the line width of text, setting with pica points allows the presentation of English texts with the same cap height, but smaller line widths because there are no accents to collide with descenders of the line above. There is in fact a simple conversion method from Didot points (new typographic points) to mm: The ratio of cap height to bodysize is 2:3. Similarly, $1\text{p} \times \frac{2}{3} = 0.375 \times \frac{2}{3}$

=0.25 mm. Thus, one can arrive at the cap height in mm by dividing the bodysize in points by 4.

4p bodysize = 1 mm cap height.

The same is true for pica points as shown above.
Rasters of 50 × 50 and smaller are known as
- low resolutions,

Rasters in the 100 × 100 range and more are known as
- high resolutions.

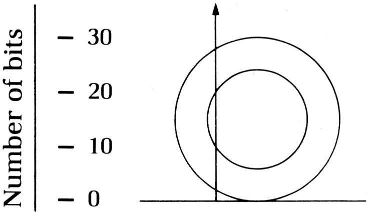
Ask any typographer and he could greatly expand this chapter and go into much more detail. However, we shall stop with the traditional terms here in the hope that we have not generated too much boredom.
See appendix F for a short listing of English, French and German terms for and about typefaces.

3. The display of typefaces

Even though we really want to discuss digital formats we cannot avoid casting an initial glance at the devices which display the type characters. We would like to distinguish three separate categories, namely visual display terminals, typesetting machines and NC machines.

All machines have the following procedure in common when writing a letter: first of all the character is stored digitally somewhere in the machine or the system, either electronically or magnetically. All characters have a binary address, so that by electronic selection any desired figure can be accessed in any sequence.

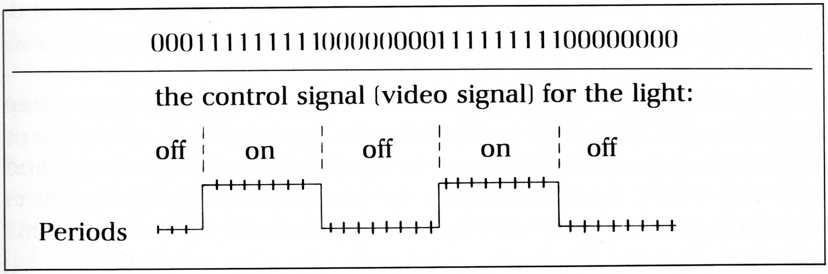
The first step is the reading of the character, i.e. the storing of the digital data in a temporary, fast access memory. The processing unit then prepares the image data digitally so that either vertical or horizontal black line segments are produced. Such a digital line then consists, for example, of an alternating series of zeros and ones, known as the bits (see sketch).



One vertical line

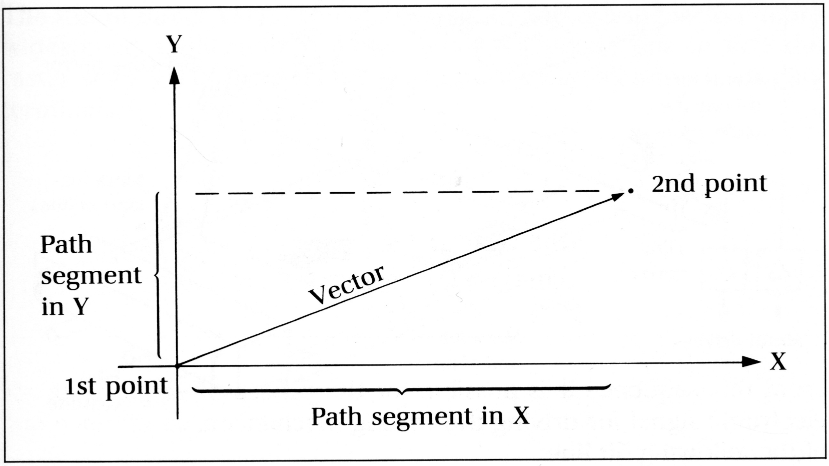
000111111111000000001111111100000

From this sequence it is possible for the processor to generate an electronic signal for driving the writing mechanism, to produce out of the following bit line

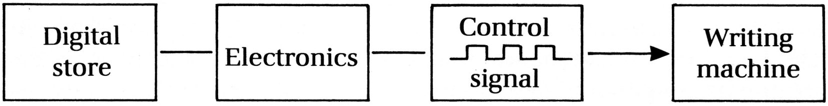

00011111111100000000011111111100000000
the control signal (video signal) for the light:
off
on
off
on
off
Periods

The beam of any particular machine has a certain thickness, determining line width and separation.

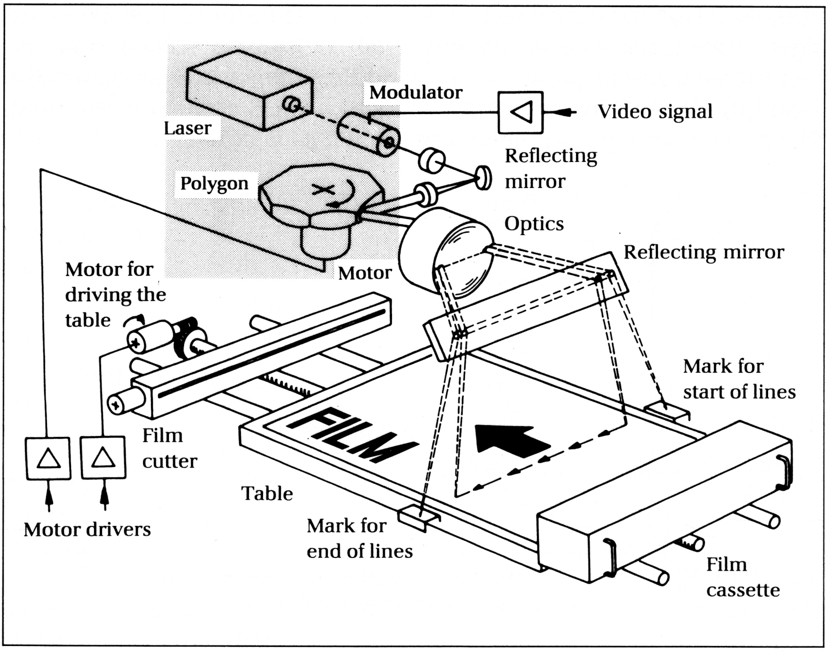
NC machines, and also some graphic visual displays prepare their control signals in a different manner. These machines can direct their writing devices from point to point in a horizontal and a vertical direction simultaneously. The stored digital data is used to generate two parallel control signals, one for movement in the X direction, the other for a simultaneous movement in the Y direction. The signals themselves contain the number of unit steps for the movement from point to point, whereby adding the path segments in the X and the Y direction together produces a short straight movement. These short straight segments are known as vectors.


Y
2nd point
Path segment in Y
Vector
X
1st point
Path segment in X

Visual display devices and typesetting machines, on the other hand, generate lines either parallel or perpendicular to the writing direction, and then move from line to line.
Thus: all three machine groups can describe a surface by generating signals for the X and the Y directions.
The point of greatest interest for us is what the machines write and how the results appear. For this reason we have generally abbreviated the electronic mode of function in each machine as follows:


Digital store
Electronics
Control signal
Writing machine

We have found a simplified illustration which shows how the control signals and light source interact in a laser typesetter (see below).


Modulator
Video signal
Laser
Reflecting mirror
Polygon
Optics
Reflecting mirror
Motor for driving the table
Motor
Mark for start of lines
FILM
Film cutter
Table
Motor drivers
Mark for end of lines
Film cassette

3.1 Visual display devices

In the case of visual display devices, the control signals are utilized to divert the electron beam of a cathode ray tube (CRT). The electron beam then impinges on a phosphorescent layer, the screen, and generates a bright point.

One can classify visual display devices (=VDT, video display terminals) into two groups: raster scan VDTs, which are similar to normal TV appliances and direct visual display terminals (direct VDTs) which are similar to oscilloscopes. The first use a system whereby the image is generated electronically line by line horizontally and displayed on the screen. This system first appeared in 1970 as a computer console development, and is mainly used nowadays as an alphanumeric data display terminal for data acquisition and monitoring, and also as a graphic display terminal of the second generation. In the case of the direct VDTs, the image is built up in a manner similar to that of an NC machine. The visual lines form the drawing or graphic. The movement of the electron beam is simultaneous in both the X and Y directions. Such graphic display monitors were already connected to computers in the early '60s, often had light pens attached, and were used in the manufacture of PC boards for example.

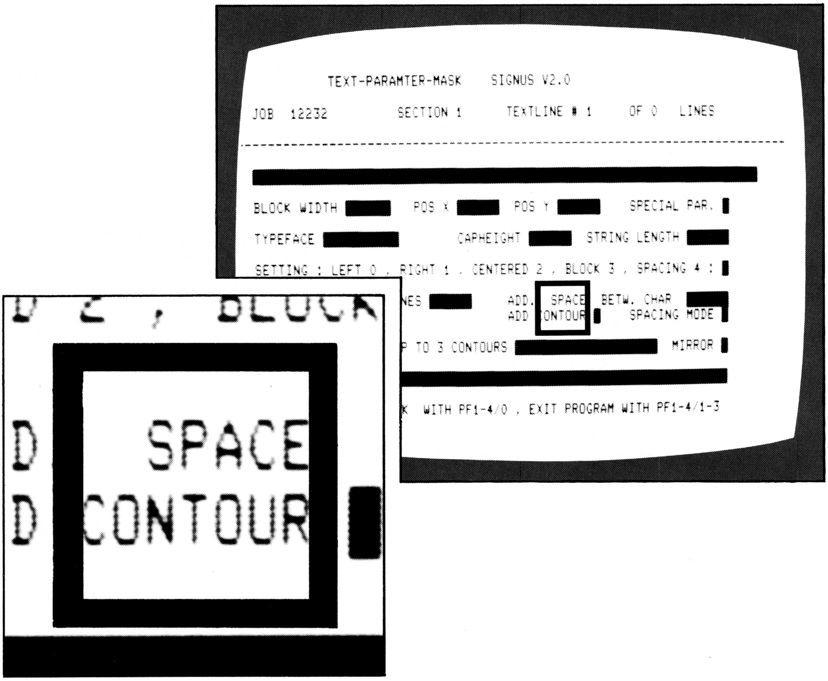
The use of direct VDTs (storage display) really expanded to a more widespread application in the early 1970s, and starting in 1975 the raster scan VDTs have found many uses as alphanumeric display terminals.

First generation display terminals

Such display terminals have a light beam which travels line by line from the left to right of the screen. Neighbouring raster points are joined to form one line, whose length corresponds with the number of points for which the electron beam was turned on. For the digital display of letters relatively small rasters for the em are used (e.g. 8 × 10).

In the following series of pictures, the pairs of images have the following relationship: the first photograph shows the full view of the graphic display terminal, the page composed or the paper drawing (depending upon device group). This produces different reductions. The second photograph shows a 5:1 enlargement of four square centimeters of the original surface on which the letters are displayed.

The first pair, below, shows the image of letters on a normal display unit. The resolution is approximately 2 lines/mm or 50 lines/inch.

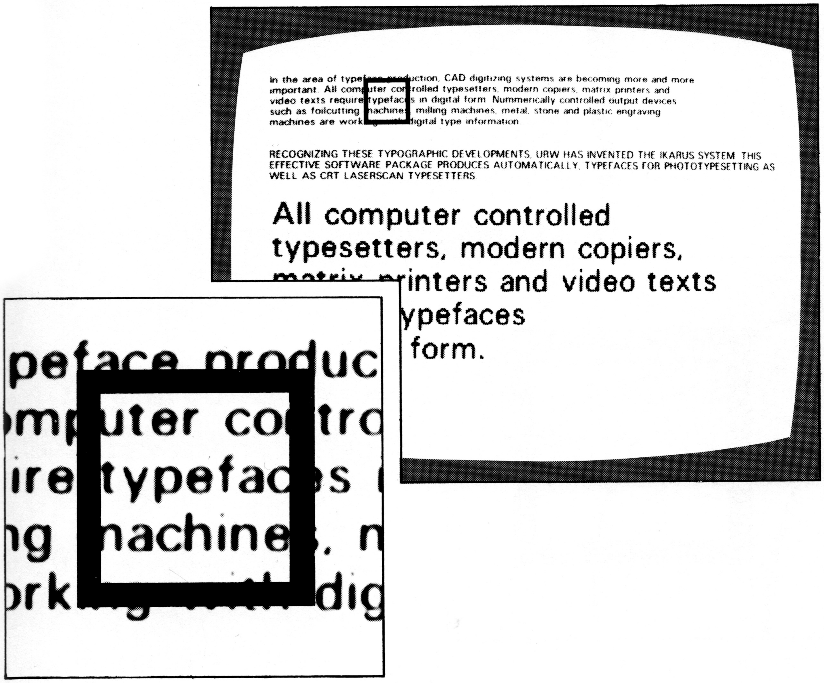


```
        TEXT-PARAMTER-MASK    SIGNUS V2.0
JOB  12232          SECTION 1        TEXTLINE # 1     OF 0   LINES
-------------------------------------------------------------------------

BLOCK WIDTH        POS X         POS Y          SPECIAL PAR.
TYPEFACE                 CAPHEIGHT       STRING LENGTH
SETTING : LEFT 0 , RIGHT 1 , CENTERED 2 , BLOCK 3 , SPACING 4 :
                  NES          ADD. SPACE  BETW. CHAR
                               ADD  ONTOUR      SPACING MODE
                  P TO 3 CONTOURS                     MIRROR

                  K  WITH PF1-4/0 , EXIT PROGRAM WITH PF1-4/1-3
```

```
D 2 , BLOCK
D    SPACE
D CONTOUR
```

Second generation display terminals

Display terminals of this type operate basically in the same way as the alphanumeric raster display terminals of the first generation, except that they store 16 × 16 half bytes per letter, use more lines and need not necessarily write monospaced. The result of all these improvements is that the processing electronics have to work 16 times faster. The resolution is approximately 4 lines/mm or 100 lines/inch.



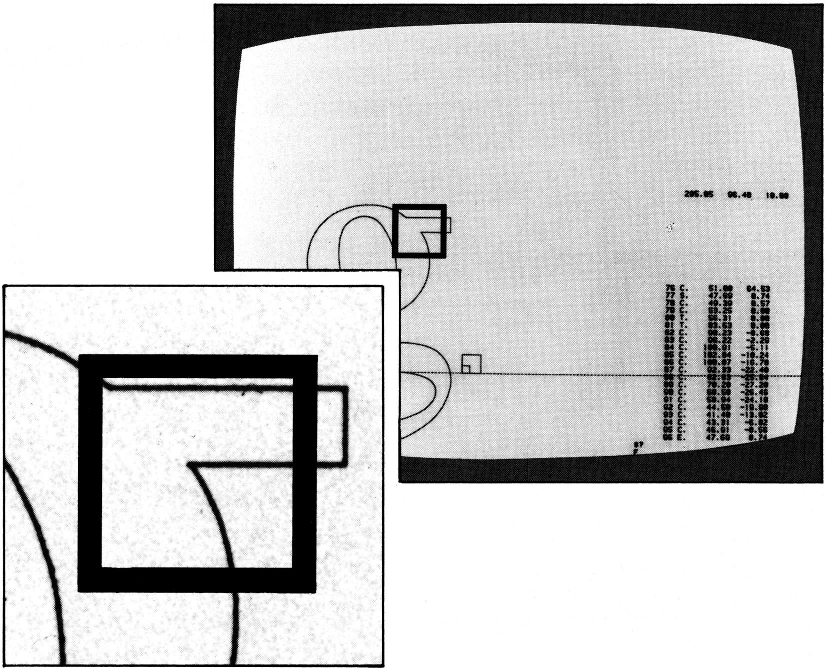
In the area of typeface production, CAD digitizing systems are becoming more and more important. All computer controlled typesetters, modern copiers, matrix printers and video texts require typefaces in digital form. Nummerically controlled output devices such as foilcutting machines, milling machines, metal, stone and plastic engraving machines are working with digital type information.

RECOGNIZING THESE TYPOGRAPHIC DEVELOPMENTS, URW HAS INVENTED THE IKARUS SYSTEM. THIS EFFECTIVE SOFTWARE PACKAGE PRODUCES AUTOMATICALLY, TYPEFACES FOR PHOTOTYPESETTING AS WELL AS CRT LASERSCAN TYPESETTERS.

All computer controlled
typesetters, modern copiers,
inters and video texts
ypefaces
form.

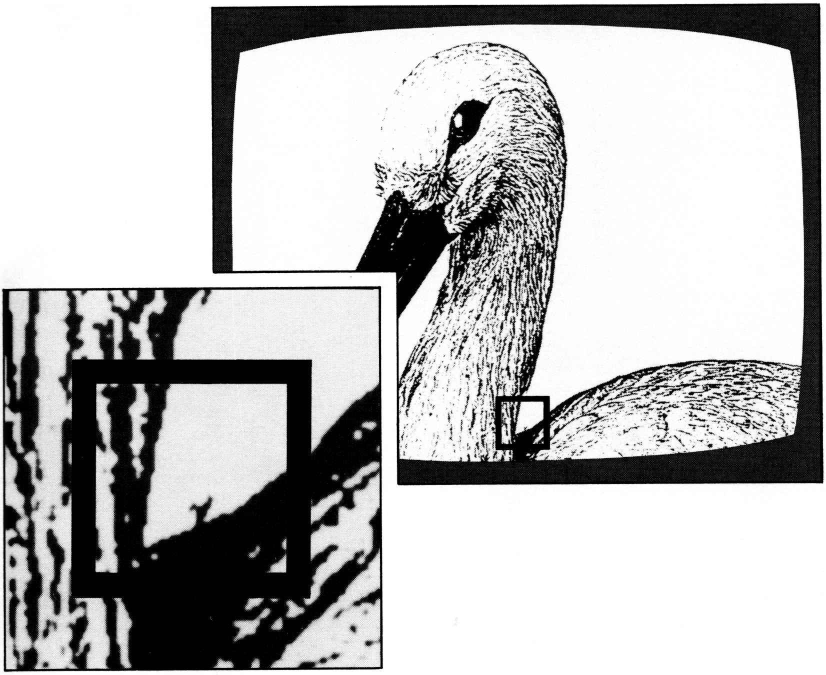
First generation graphic display terminals

Graphic display terminals of the first generation (direct VDTs or storage displays) have very fast line generators for the X and Y control of the electron beam. The data to be displayed is stored graphically as vectors. Each vector links two points (knots). The resolution may be up to 10 lines/mm or 250 lines/inch, the width of the electronic beam is, however, only 4 lines/ mm or 100 lines/inch.



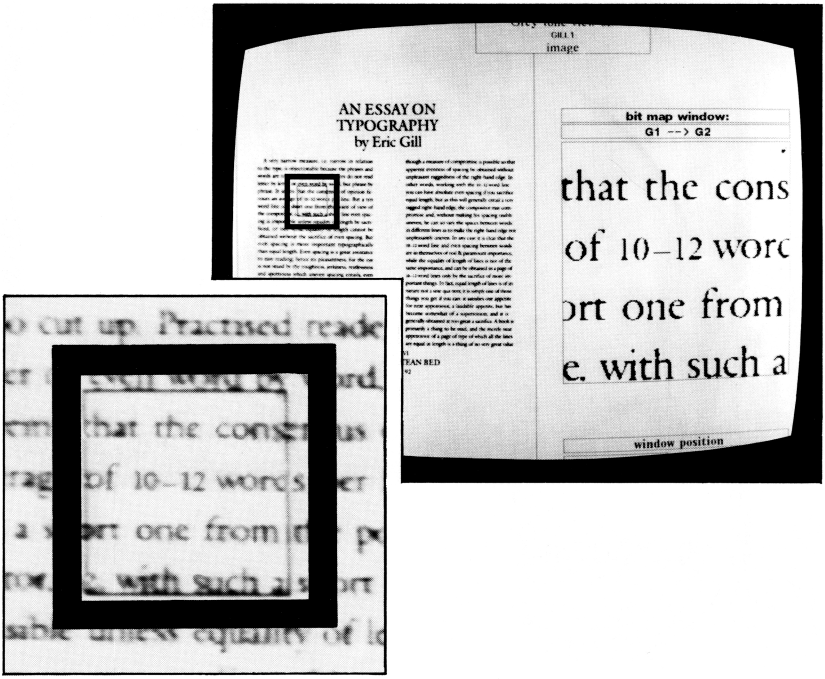
Second generation graphic display terminals

This class of graphic display terminal, the raster display terminals, generate their entire screen display (e.g. 600 lines each with 800 points) from a corresponding bitmap of 800 × 600 bits. These display terminals are gradually taking over from storage display terminals. The line imaging is slightly worse but they have less difficulty in filling in screen areas with black or white. Resolution is up to 4 lines/mm or 100 lines/inch.



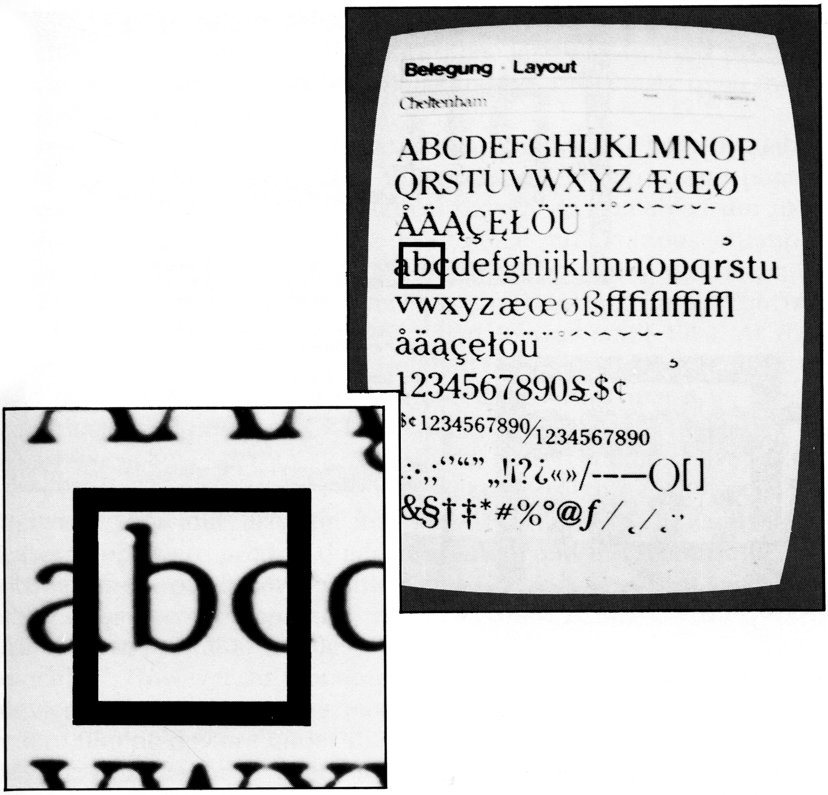
Second generation graphic display terminals with halftone display

A relatively recent development is the raster display terminal which can display not only black or white points but also various intermediate gray tones. The image of the pixels is read from a quarterbyte, halfbyte or bytemap with corresponding four (quarterbyte), 16 (halfbyte) or 256 (byte) gray tones. Lines are well imaged. Resolution is up to 4 lines/mm or 100 lines/inch.

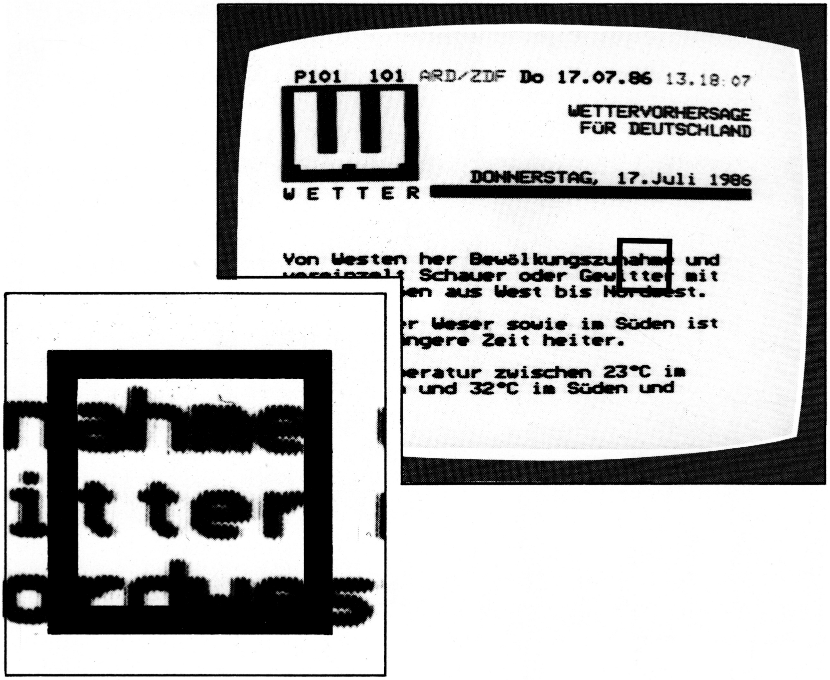

GILL1
image
AN ESSAY ON
TYPOGRAPHY
by Eric Gill
bit map window:
G1 --> G2
that the cons
of 10–12 worc
ort one from
e. with such a
window position

TV

The type displayed on normal TV screens has two main sources. Either a TV camera focussed directly on the object:


Belegung · Layout
Cheltenham
ABCDEFGHIJKLMNOP
QRSTUVWXYZÆŒØ
ÅÄĄÇĘŁÖÜ
abcdefghijklmnopqrstu
vwxyzæœøßfffiflffiffl
åäąçęłöü
1234567890£$¢
$¢1234567890/1234567890
&§†‡*#%°@ƒ
abc

or the type is produced by a typesetting processor and mixed into the analogue videosignal. Standard resolutions are approximately 2 lines/mm or 50 lines/inch.



P101 101 ARD/ZDF Do 17.07.86 13.18:07

WETTERVORHERSAGE
FÜR DEUTSCHLAND

WETTER

DONNERSTAG, 17.Juli 1986

Von Westen her Bewölkungszunahme und
vereinzelt Schauer oder Gewitter mit
en aus West bis Nordwest.

r Weser sowie im Süden ist
ngere Zeit heiter.

eratur zwischen 23°C im
und 32°C im Süden und

3.2 Typesetting machines

For the purpose of this book typesetting machines include: matrix printers, electrostatic printers, laser printers, microfilm devices, CRT machines, laser film recorders and other less widely used printing machines. The term typesetting machine has previously been more limited in context.

Typesetting machines for hot metal composition have been available since 1886 (Mergenthaler), e.g. Linotype or Monotype, and phototypesetting machines for Latin letters have been available from 1949 onwards (Higonnet, Moyroud). Ever since 1922 various attempts have been made in different countries on forerunning machines; in Japan in 1923 a phototypesetter was invented for Kanji. The big breakthrough for phototypesetting had to wait until 1965. At this time, in 1964/65, Dr. Ing. Rudolf Hell had already invented the Digiset and presented the first fully electronic typesetting machine. These machines are known as CRT machines because they make use of cathode-ray tubes. From 1975 onwards, CRT machines have taken over the market and ousted hot metal composition.

Between 1974 and 1978 the first laser typesetters (Linocomp and Lasercomp) were produced and presented, and in recent times the displacement of phototypesetting and CRT machines by laser machines has become apparent.

All of these machines are described by the overall term “typesetting machine”. However, as mentioned above, we will also include other devices, e.g. matrix printers, electrostatic printers, laser printers and micro filming devices under this term.

Matrix printers have been available since 1970 and have found widespread use as a cheap alternative to fast printers (which use metal type printing characters) for printing the outputs of electronic data processing.

Over approximately the same period, the use of electrostatic printers has become more widespread in the field of computer aided design (CAD) for the generation of drawings with text. Such printers compete to some extent with plotters and drawing machines.

Laser printers have been sold with some success by XEROX from 1980 onwards. Their first real breakthrough into larger market segments is as recent as 1984. These printers, connected with PCs [personal computers] will undoubtedly be the office typewriter of the future, and will be used in the field of desk top publishing.

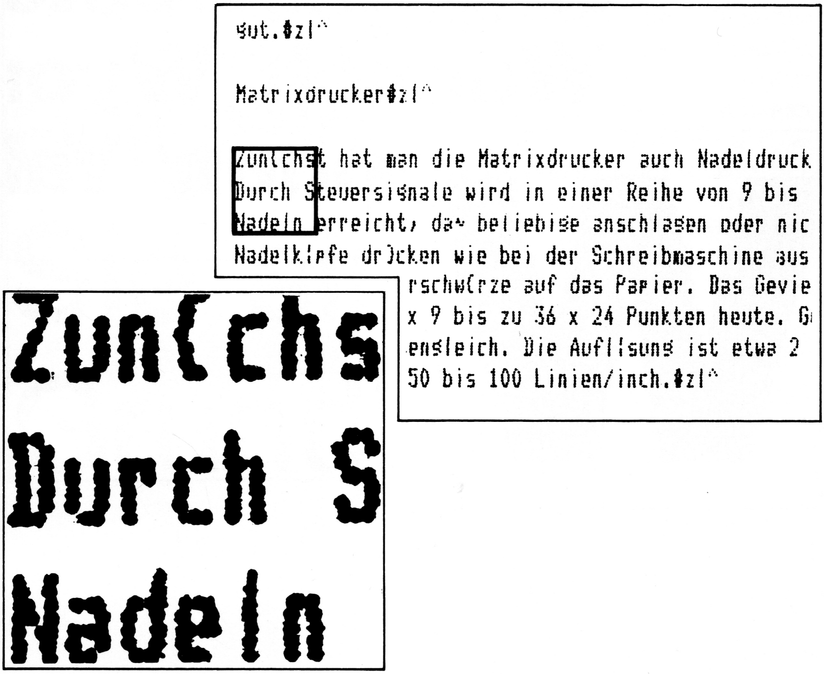
The microfilming devices represent a special variant of typesetting machine. They produce film sheets which are viewed with enlarging devices. The increasing capacity of computers and data networks probably marks the end of the use of such devices.

In summary, we think that the only devices which have a chance in the future are high resolution matrix printers [24 to 36 needles for the bodysize], laser printers and laser film recorders [laser typesetters].

Matrix printers

Matrix printers have a printing head consisting of a row of between 9 and 24 needles, orientated perpendicular to the writing direction and controlled by the control signal. The needles press printing black or ink from an ink ribbon onto the paper, similar to a typewriter. The em consists of from 7 × 9 points up to 36 × 24 points on current machines. Monospace typesetting is the norm. Resolutions vary from approx. 2 to 7 lines/mm or 50 to 180 lines/inch.

When preparing the German edition of this book, the text was only available in the form of lists printed out using a matrix printer. Reading these proofs I failed to notice many mistakes, which I only found in the text when reading the final proofs (produced by a Digiset).

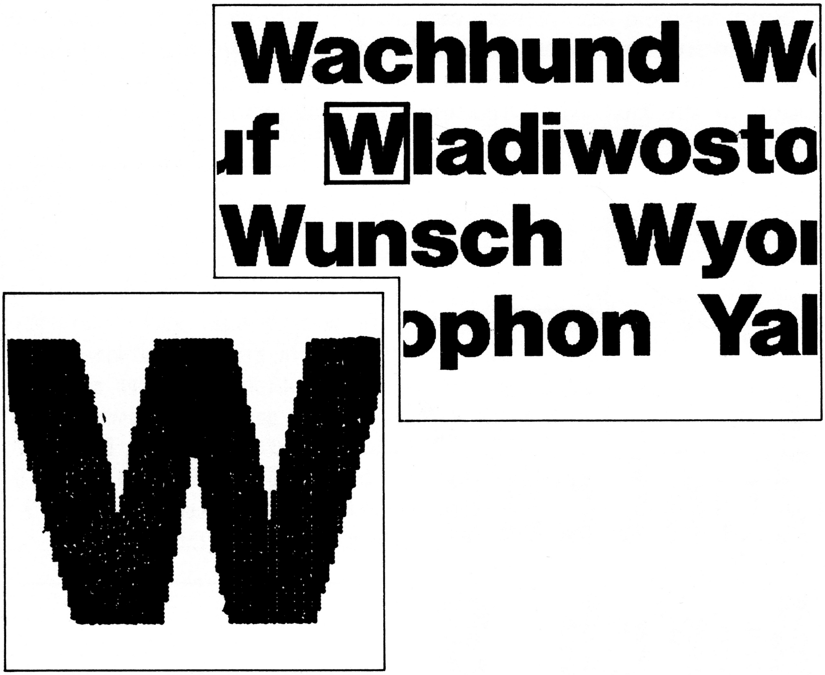


```
gut.#zl^

Matrixdrucker#zl^

Zun{chst hat man die Matrixdrucker auch Nadeldruck
Durch Steuersignale wird in einer Reihe von 9 bis
Nadeln erreicht, da~ beliebige anschlagen oder nic
Nadelk!pfe dr}cken wie bei der Schreibmaschine aus
                 rschw{rze auf das Papier. Das Gevie
                 x 9 bis zu 36 x 24 Punkten heute. G
                 ensgleich. Die Aufl!sung ist etwa 2
                 50 bis 100 Linien/inch.#zl^
```

Zun{chs
Durch S
Nadeln

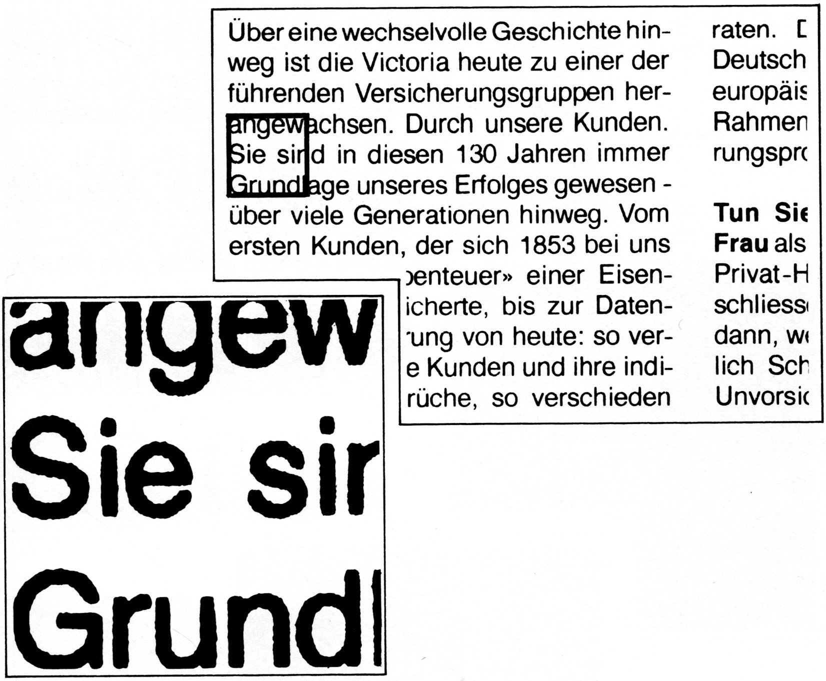
Electrostatic printers

Electrostatic printers are also known as electrostatic plotters. The control signals are used to produce electrostatic charges on lines running parallel to the writing direction, which then attract ink particles. These ink particles are absorbed by the paper and produce the print. Typical resolution values are 8 lines/mm or 200 lines/inch, newer machines are capable of 16 lines/mm or 400 lines/inch.



Laser printers

Laser printers work on a principle similar to electrostatic printers. Use is made of a well focused light beam which may be turned on and off and directed to produce electrostatic discharge of highly charged ink particles. In general, resolutions are between 12 and 32 lines/mm or 300 and 800 lines/inch in both X and Y direction.



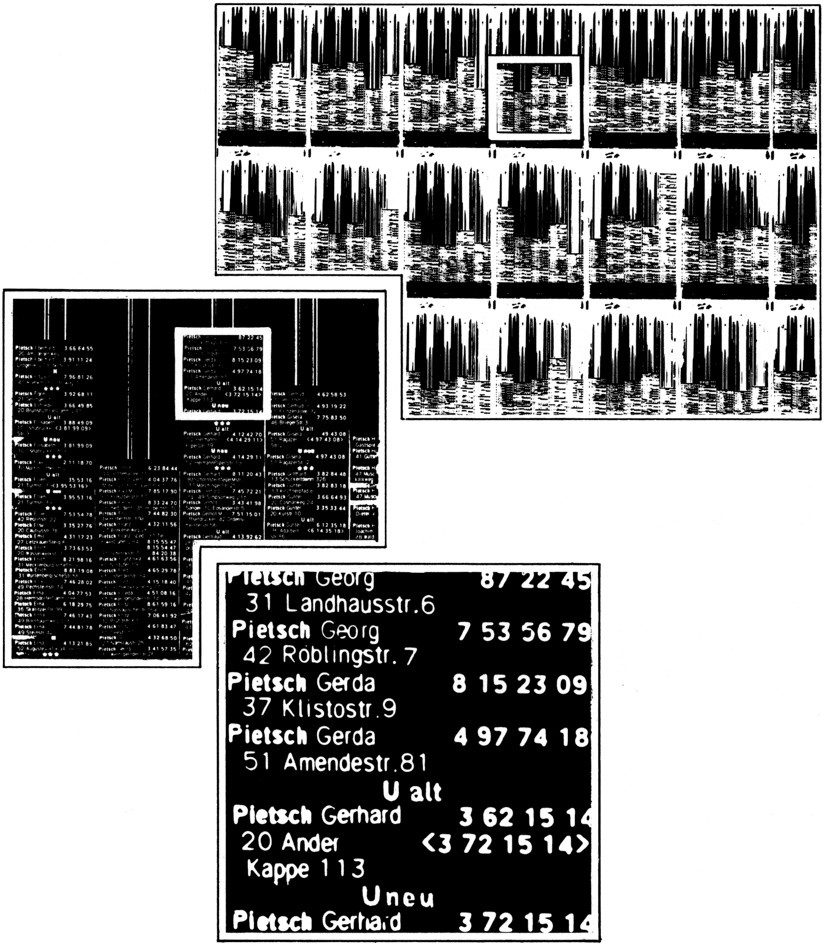
Über eine wechselvolle Geschichte hinweg ist die Victoria heute zu einer der führenden Versicherungsgruppen herangewachsen. Durch unsere Kunden. Sie sind in diesen 130 Jahren immer Grundlage unseres Erfolges gewesen - über viele Generationen hinweg. Vom ersten Kunden, der sich 1853 bei uns
ɔenteuer» einer Eisen-
icherte, bis zur Daten-
'ung von heute: so ver-
e Kunden und ihre indi-
rüche, so verschieden

raten. Ľ
Deutsch
europäis
Rahmen
rungspro

Tun Sie
Frau als
Privat-H
schliess
dann, w
lich Sch
Unvorsic

Microfilming devices

In microfilming devices the control signals are generated as in drawing machines. A very highly focused light beam writes the text in the form of small straight strokes. Resolution is indirectly about 300 lines/mm or 7500 lines/inch after photographic reduction.



Pietsch Georg 87 22 45
31 Landhausstr.6
Pietsch Georg 7 53 56 79
42 Roblingstr. 7
Pietsch Gerda 8 15 23 09
37 Klistostr.9
Pietsch Gerda 4 97 74 18
51 Amendestr.81
U alt
Pietsch Gerhard 3 62 15 14
20 Ander <3 72 15 14>
Kappe 1 1 3
Uneu
Pietsch Gerhard 3 72 15 14

CRT machines

CRT machines are fully electronic phototypesetting devices which make use of cathode ray tubes (CRT). They differ from normal TV screens or display terminals in that the electron beam is extremely sharply focused. The light on the display surface is used to expose films. An optical lens system is placed between the display and the film. On film, resolutions of between 25 to 100 lines/mm are possible in both directions (vertically and horizontally), or 625 to 2500 lines/inch. Type reproduction is very good. Typesetting speeds are anything up to 2000 characters/second.

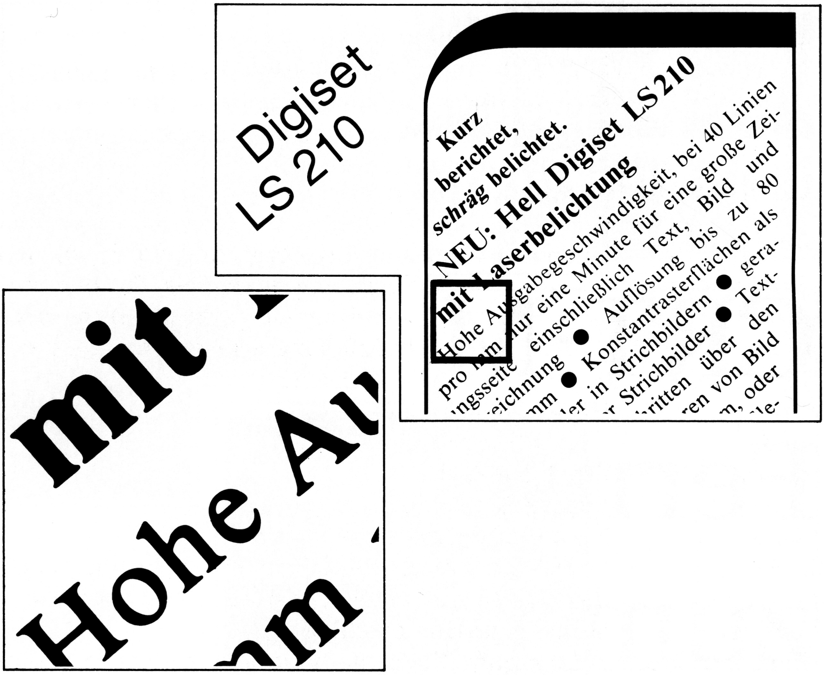
CRT-Maschinen

CRT-Maschinen sind vollelektronische Lichtsetz
Fernsehröhre (Cathod Ray Tube = CRT) verwend
zum normalen Fernsehen oder den Sichtgeräten is
strahl in diesen Geräten sehr gut fokussiert. Das Li
schirm wird zur Belichtung von Filmen verwendet
gerät und Film befindet sich eine Linsenoptik. Auf
man eine Auflösung zwischen 25 bis 100 Linien/m
und horizontal) bzw. 625 bis 2500
Schrift ist sehr gut. Die Setzgesch
hen/Sekunde.

CRT-M
Fernse
zum n

Laser film recorders

In laser film recorders laser light is used directly to expose films. The control signals move a light spot (or several) across the film and switch it on or off. Resolution and composing speed are comparable with those of CRT machines, although mostly they are faster. In conjunction with these typesetters we have, for the first time, a machine which can rotate characters arbitrarily. Other machines are also able to do this (theoretically), but as far as we know this has only been realized up to now in one machine. The resolution is typically between 50 to 100 lines/mm or 1250 to 2500 lines/inch.


Digiset
LS 210
Kurz
berichtet,
schräg belichtet.
NEU: Hell Digiset LS210
mit Laserbelichtung
Hohe Ausgabegeschwindigkeit, bei 40 Linien
pro mm nur eine Minute für eine große Zei-
tungsseite einschließlich Text, Bild und
Zeichnung ● Auflösung bis zu 80
mm ● Konstantrasterflächen als
in Strichbildern ● gera-
Strichbilder ● Text-
über den
von Bild
oder
mit
Hohe Au
mm

Other typesetting machines

Typesetting machines are available with other methods of operation, e.g. ink jet printers or laser vaporization machines for direct exposure of printing plates.

At this point, however, we would like to limit ourselves to providing a brief summary of the ways and means by which digitally stored letters may be displayed, and would rather not go into details of the many variations.

It will become clear that all machines require their own particular type of digital coding. Correspondingly, the required resolutions favour certain coding techniques: for display terminals or matrix printers, bitmaps, for resolutions around 20 lines/mm, scanline coding, for very high resolutions, outline coding. This results from the necessity of keeping the type storage requirement in a machine as small as possible in all cases.

3.3 NC machines

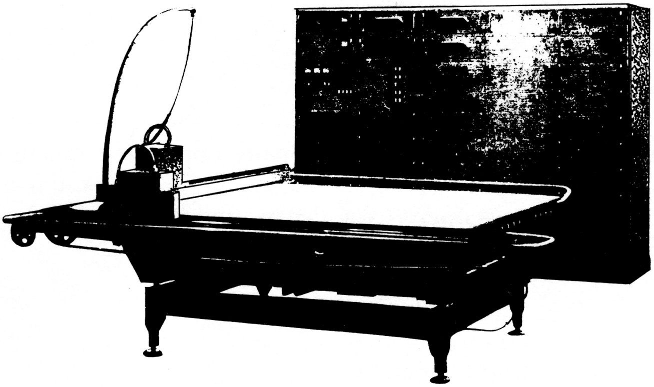
The term "NC machine" (i.e. numerically controlled machine) was chosen as the group name for the following machines. For our purposes these machines operate on a very similar principle, they move a "pen" in the X and the Y direction simultaneously and one differentiates between the actual writing instrument:

Pen – Drawing machine or plotter
Knife – Foil cutting machine
Router – Routing machine
Engraver – Engraving machine
Flame – Flame cutting machine
Laser beam – Laser cutting machine or laser engraving machine
Water jet – Beam cutting machine (pressure cutting machine)
Sand jet – Stone engraving machine

The control signals all require the same treatment, similar to that of direct VDTs and microfilming machines. In the case of NC machines however, one usually requires relatively powerful motors to produce the actual movement in the X and Y direction.

On the other hand, having the same sort of control signal means that the digital storage of type is the same for all of these machines.

So, plotters are also capable of writing, but are extremely slow compared with laser composers. A "typesetting speed" of 1 character per second is common. Nowadays writing instruments can often be moved with speeds between 1 cm/sec and 1 m/sec.
The early 1950s saw the development of numerically controlled machine tools in the USA. The initial beginnings of large flat bed plotters from 1950 to 1960 may be traced back to Konrad Zuse and the ARISTO company. Whereas Konrad Zuse kept to a rigid digital development of the X and Y axis drives using stepping motors, at ARISTO DC motors were used on a digital-analog basis. In 1959 the first "ARISTO Coordinatograph with numerical continuous path control" was presented.

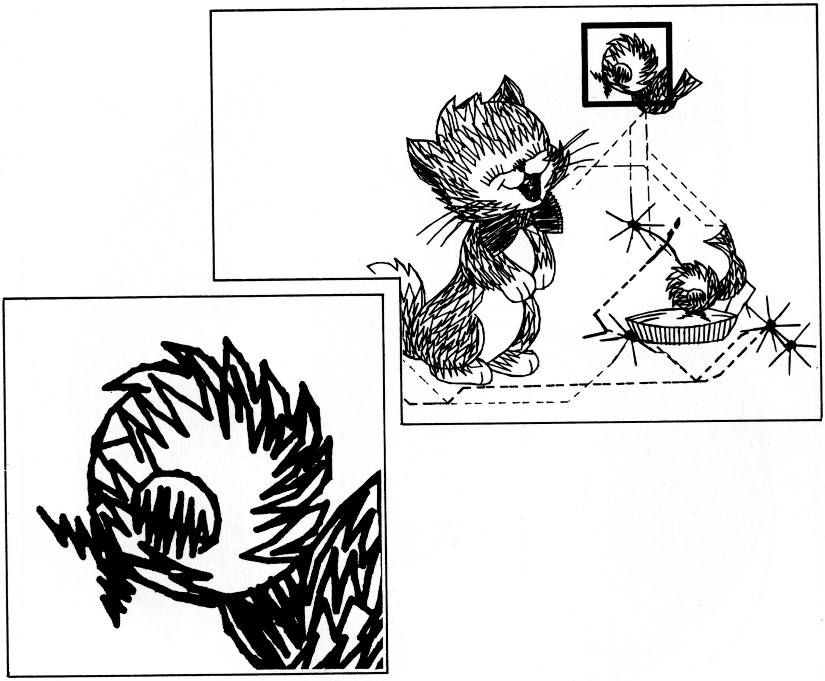


Aristomat with continuous path control, 1959

Flat bed drawing machines available today are a development of this and have working areas of about 1 m² up to 2 m².
These machines work at high drawing accuracies of 1/100 mm and are expensive for this reason. Smaller plotters are more reasonably priced. They have working areas corresponding to A3 format, and a drawing accuracy of 1/10 mm.
Three different NC machines are described on the following pages.

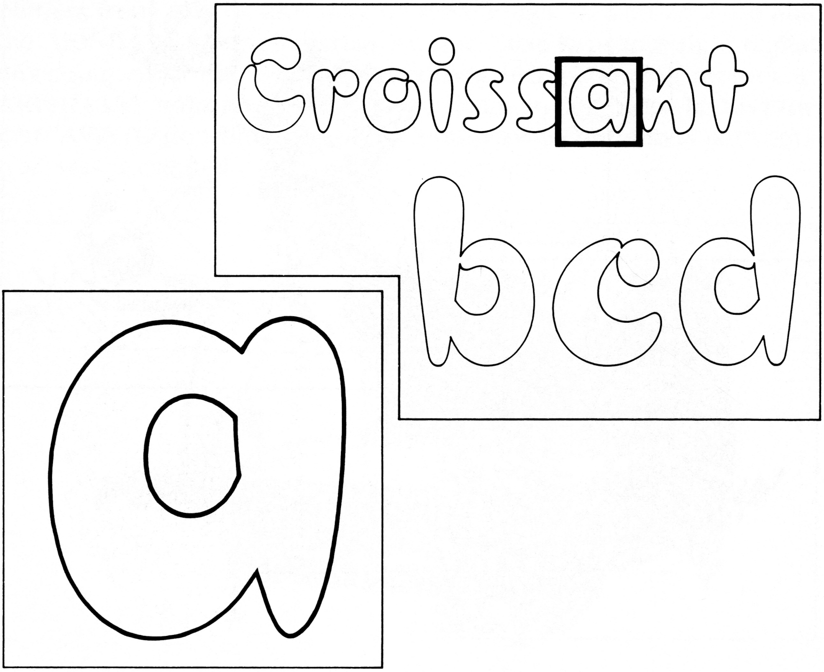
Plotters

The smaller plotters have a resolution of approximately 0.1 mm up to 0.025 mm or 0.004 inch up to 0.001 inch, which corresponds to 10 to 40 lines/mm or 250 to 1000 lines/inch.



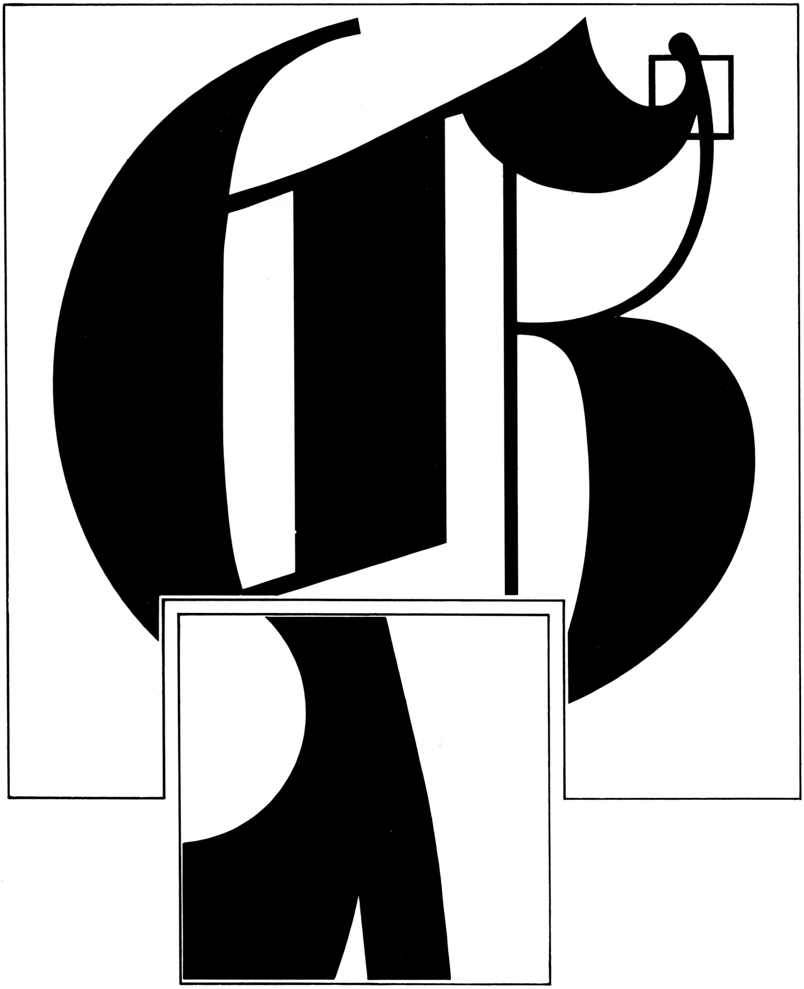
Flat bed drawing machines

The larger flat bed plotters actually have earned the description “drawing machine”. They do have resolutions of 0.025 mm up to 0.005 mm or 0.001 inch up to 0.0002 inch, corresponding with 40 to 200 lines/mm or 1000 to 5000 lines/inch. These are more than mere plotters!



Foil cutting machines

Most flat bed drawing machines can also be used to cut laminated films. As you can see, we have reproduced a very nice, large letter to show the precision which cutting can achieve.



4. Requirements of typesetting

It is obvious that the different machines and the different electronic modules in the machines require different coding. In each case the digital storage for a certain machine has to be carried out in a manner whereby the type takes up as little space as possible, and can be read and processed as quickly and directly as possible. This is achieved by the optimum matching of the type code to the electronics used. The requirements placed by the machine on the digital format of the typefaces limit themselves for the most part to the code. The actual display of the texts, the typesetting, however increases the requirements.

4.1 Type structure

The initial requirement is that the data stored respective to each individual letter is accessible. To this end the letters have addresses and are listed in the letter index table.

Secondly, the left side bearings, right side bearings, and total widths of the characters have to be accessible independently of the image data. The widths are therefore stored in the form of separate data tables known as width tables. Accents present slightly more of a problem if they are treated as floating accents, related to the letters in the form of marked positions, and only arriving at these marked positions in the actual typesetting. This is possible using either a typesetting rule whereby an e and ` produce an è, or, with the aid of marking an e and ` the typesetting produces an è (` mark on e mark). We consider fixed accents to be better, i.e. extra letters for: è, é, ê, ñ, å, ë, ô etc; because accented letters are individual characters and should, as such, be checked by the type designers at the type design stage.

Ligatures are also important – as already referred to in chapter 2. They were created in order to produce an improved appearance for certain letter combinations, and can greatly enhance the overall appearance of well spaced text.

In addition, one has to deal with swash characters, e.g. an “e” with an extended embellished stroke on its terminal, used at the end of a word instead of a normal “e”, which is used at the beginning and in the middle of words.

These three examples – accents, ligatures, swash characters – create problems when entering text [on English keyboards for VDTs] where initially only the normal individual characters can be entered. Downline software is then used to find the new addresses for fixed accent letters, ligatures or swash characters. Not many text systems are capable of doing this at the moment.

It is now clear why a comprehensive description of a typeface [see also appendix B] is required.

It may be necessary to store particular number values, e.g.

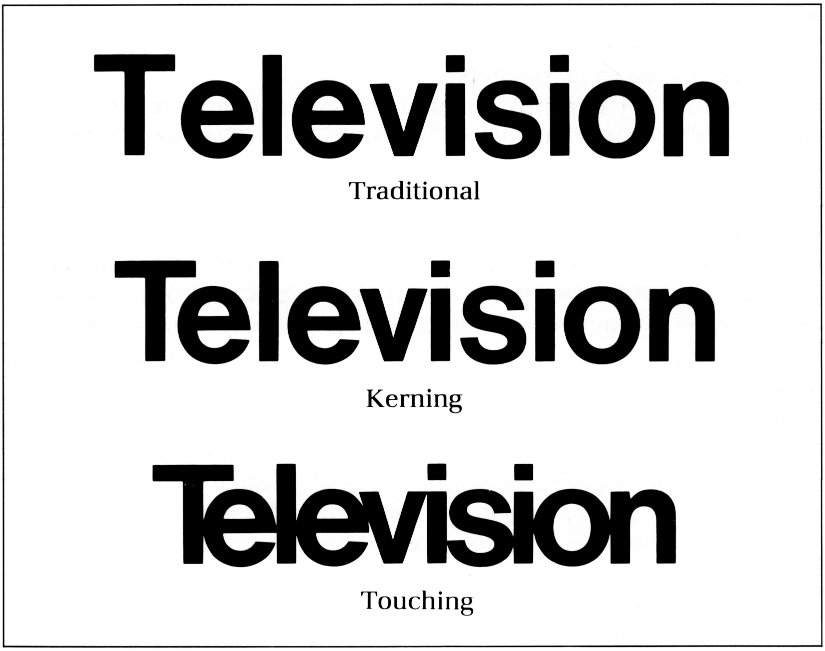
- for superior indices [superscripts] and
- for lower indices [subscripts].

Furthermore, kerning and touching tables also belong to a particular typeface. The proper meaning of kerning has already been discussed in chapter 2.

Many producers of machines and type have not yet got around to dealing with kerning. Some companies – but by no means all – produce so-called aesthetic boxes, which provide correction values for certain important letter pairs. As an example, the illustration below is a list of letter pairs for which the Berthold Company is able to provide kerning values. As a rule these are negative values which are used to correct [reduce] the traditional letter spacing using set widths.

AT AY AV AW Ay Av Aw A’ FA F. F, TO TA Ta Te
To Ti Tr Tu Ty Tw Ts Tc T. T, T: T; T- LT LY
LV LW Ly L’ PA P. P, VA Va Ve Vo Vi Vr Vu Vy
V. V, V: V; V- RT RV RW RY f’ WA Wa We Wo Wi
Wr Wu Wy W. W, W- YA Ya Ye Yo Yi Yp Yq Yu Yv
Y. Y, Y: Y; Y- r’ r. r, r- y. y, v. v, w. w,
’s

At URW a completely different concept is used: the distance between any two letters is an individual value from first principles, i.e. at URW the kerning table for 100 characters, for example, has a length of 100 × 100 = 10,000 words, for 250 characters it has a length of 250 × 250 = 62,500 words. This means that aesthetic tables are a great deal smaller than the large kerning tables provided by URW. A special table is prepared for every type font.
In addition to the kerning values, there are also correspondingly structured touching tables allowing the spacing between letters to be reduced still further, letting them touch. Safety zones ensure that, for example with “HIH” in Helvetica, the letters do not touch.



Traditional

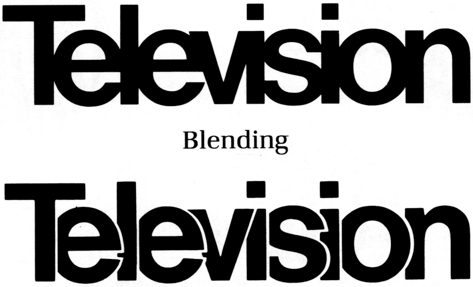
Kerning

Touching

The overlapping table allows pairs of letters to approach each other so that they overlap – known also as sexy setting. Blending is where the black areas of the letters blend into one another and overlapping is where thin white edgelines outline the covering letter.

In everyday use, touching values are only required when setting "headline type" (cap height above 1 cm at normal reading distance) for correcting the kerning values. When doing so one uses the following rule:

The larger the letters the more kerning approaches touching.



Blending

Overlapping

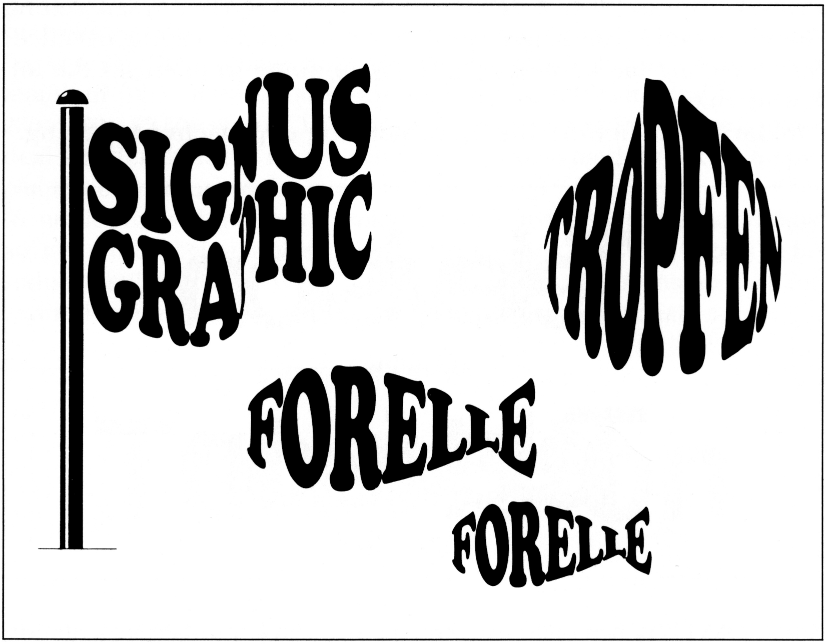
Since 1983 URW has been using an algorithmic automatic calculation system which took three years to develop and which deals not only with traditional spacing but also kerning, touching and overlapping tables; a very complicated system. The results calculated are then checked using typesetting examples, and where necessary, are improved manually.

In appendix R we have described the data structure for all spacing, and in appendices S, T, U and V the set-up of the width, kerning, touching and overlapping tables.

4.2 Form setting

Form setting means the setting of lines not running in horizontal straight lines, i.e. the setting of sloping, circular, wavy and other lines.

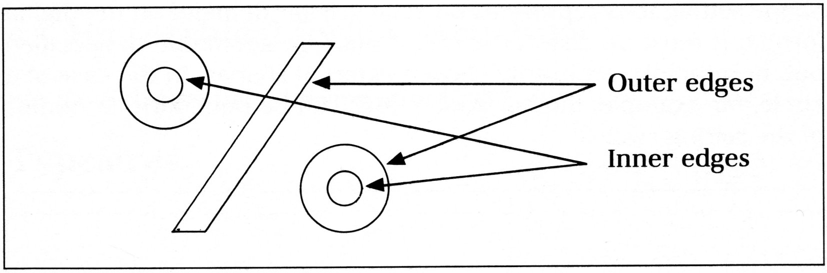
A few examples of form setting are shown below:



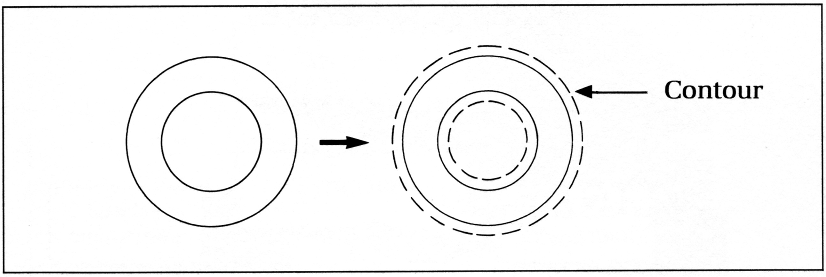
The term form setting also means however, the mathematical formula tables, table typesetting, the typesetting of graphic elements such as lines, frames, vignettes and in general all other possible requirements for the successful setting of advertisements. And furthermore, the setting of type along the contours of such geometric elements, or otherwise in combination with such elements may not be disregarded or forgotten.
Form setting therefore requires additional data:

- Body size in original data base
- Cap height
- x-height
- Stroke thickness of type (weight)
- Optimum size range for the typesetting,
- Width (traditional, kerning, touching, overlapping).

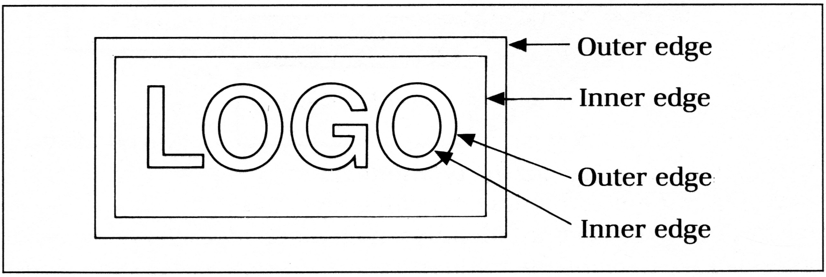
In addition, all codes must identify which inner edge relates to which outer edge, especially for contouring.


Outer edges
Inner edges

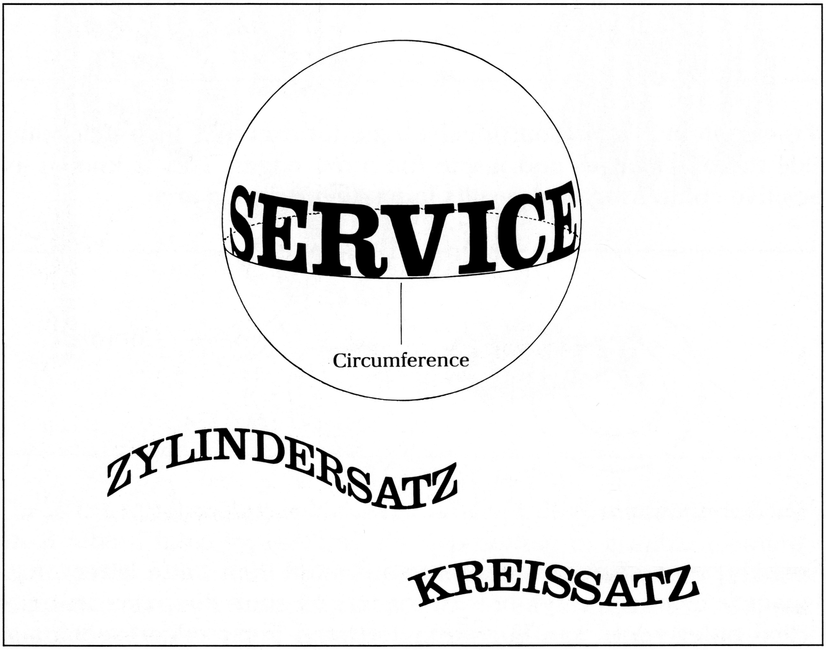
If the contour is to run outside the letter for example, then it lies outside the outer edges and inside the inner edges. This is known as positive contouring, and results in a larger printing area.



Consider type characters more complicated than Latin letters, e.g. Japanese characters, symbols or logos; one soon discovers that so-called outer edges can lie within so-called inner edges and inner edges can be inside these as well, and so on.


LOGO
Outer edge
Inner edge
Outer edge
Inner edge

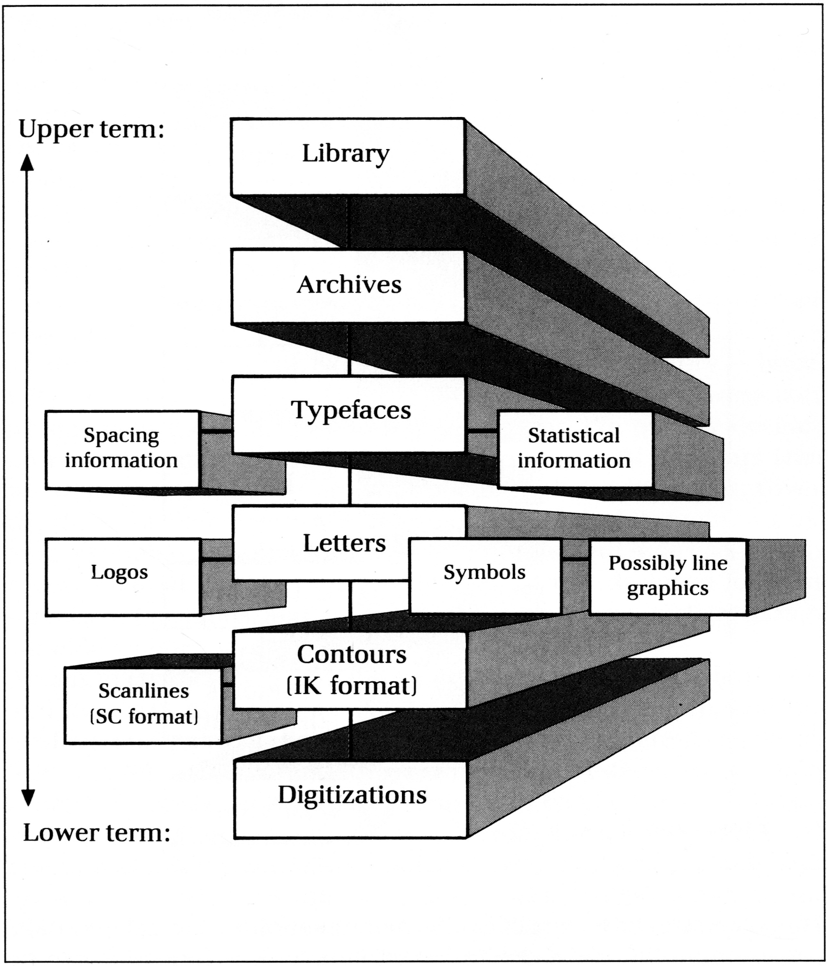
Shape setting thus represents an even greater demand on the digital format. It must be distortable, i.e. it must be adaptable to specified but, in principle, arbitrarily chosen external shapes. In the case of a circle, for example, the horizontal lines can be bent with the radius of the setting circle.


SERVICE
Circumference
ZYLINDERSATZ
KREISSATZ

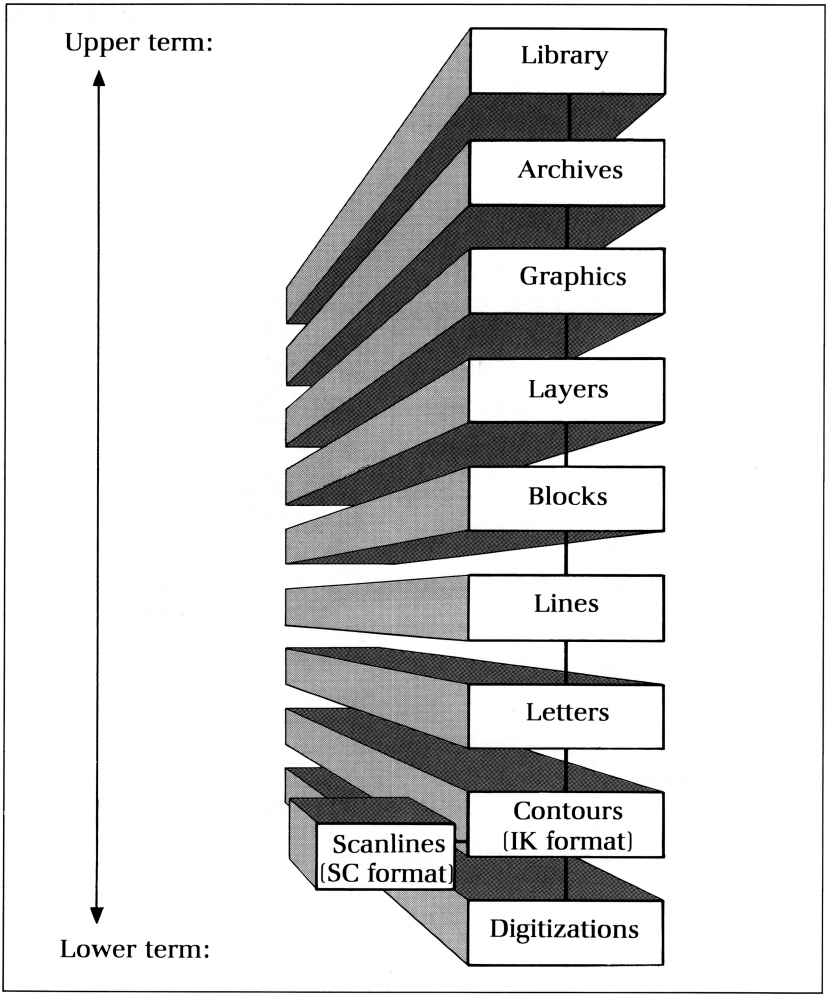
4.3 Hierarchical format structure

We have chosen the following structure:

Typefaces


Upper term:
Library
Archives
Typefaces
Spacing information
Statistical information
Letters
Logos
Symbols
Possibly line graphics
Contours (IK format)
Scanlines (SC format)
Digitizations
Lower term:

Graphics


Upper term:
Lower term:
Library
Archives
Graphics
Layers
Blocks
Lines
Letters
Contours
(IK format)
Scanlines
(SC format)
Digitizations

This data structure simplifies the manipulation of the related data. For example the copy, delete, insert and replace functions can be applied especially to a chosen hierarchy plane, i.e. limited to the elements of one hierarchical level.

In appendix G there is an exact description of the typeface structure and in appendix H the structure of a graphic form in the IKARUS system.

In the framework of storing typefaces, a special structure is required for the "typeface" level and below. The actual host file management system should be used for the levels above typeface.

The storage of graphics requires a far more complex structure than that required for typefaces, though in other respects a graphic is treated hierarchically as a typeface or, if the graphic is simple, as a character.

In our experience the functions for typeface and graphic – as for example IKARUS modifications – are too slow if the files for the characters and graphics are not structured. Please note, we implement the IG format for this structuring, since we regard this format as the most suitable. This is the shortest of all available formats (see chapter 6.3).

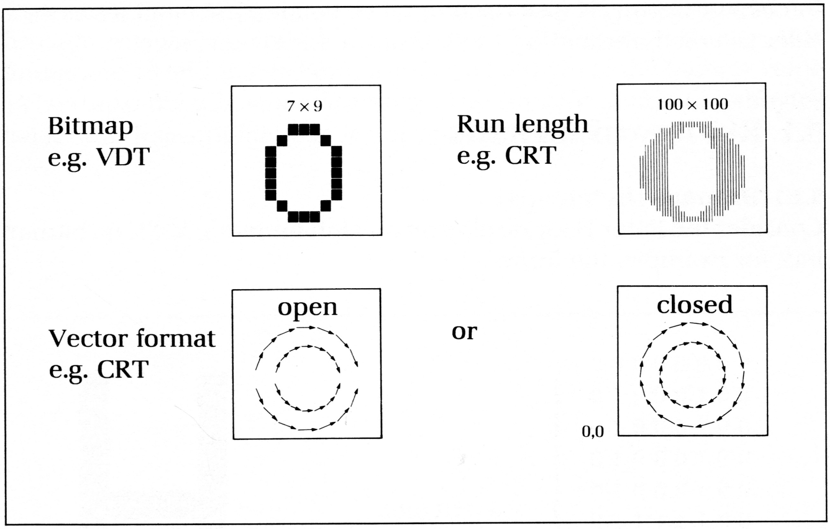
At this point we would like to indulge in a little history – hopefully the reader will bear with us. Twelve years ago we were confronted with the problem of storing typefaces. We quickly decided on random access because of the quick disc access! Six years later we were posed with the problem of storing Kanji typefaces. Given the then available 5 to 10 MB discs our "random" philosophy was no longer suitable. We therefore decided to implement index sequential access method (ISAM). Unfortunately, ISAM was designed for commercial applications, and not for quick access to single characters of variable length.

Access to characters means above all loading one typeface into RAM and then processing many characters from this typeface, and not loading numerous individual characters from different typefaces from the disc. Normal ISAM file management systems are not fully capable of managing this relationship between characters and typefaces but are designed for searching for individual elements. Our element is – and this we learnt the hard way – the typeface, the large graphic, the collections of frames for images or line elements, and not every individual figure such as the character of a typeface, an element of a graphic, or a specific frame or line.

The developments in semiconductor memories and the advent of 32 bit microcomputers ideally suit our current, revised storage concept. At last we are able to store our critical mass, namely 20 to 100 KB for a Latin typeface as one unit, which was impossible with the previous 64 KB address barrier: a typeface is loaded as soon as only one character from this typeface is required. We then enclose the IK or IG structures with the typeface or graphic shells, enabling individual access to the desired hierarchical levels such as point, contour, etc. We recommend this procedure to all those who work with typefaces and graphics.

5. Formats

As the capabilities of electronics increased in the past so did the comprehensiveness of the digital information of the type data.
On the one hand, keeping the data compact required more highly developed control electronics, while on the other hand the greater requirements of the typesetting demanded more electronics and greater memory capacities for the type information.
Initially, the data was stored in the form of easy-to-deal-with bitmaps or run lengths, and later as outline codes; first the vector format, followed by more complex formats.



There are now a very large number of machines available using digital typefaces and thus a similarly large number of digital formats for typefaces. This variety demands categorization according to the following characteristics:

- method bitmap
  bytemap [halftones]

	run lengths vectors curves segmentation Metafont
– coordinates	absolute incremental
– code	simple complex

These last two characteristics – coordinates, code – do not necessarily mean a difference of format. In the first place absolute coordinates can be converted incrementally and vice versa, and on the other hand any complex coding can be calculated back to its simple original form (and of course vice versa).

In chapter 5.3 this is discussed in more detail. First of all let us consider the methods and try to establish a format review.

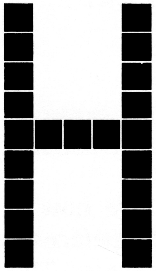
5.1 Review of formats

5.1.1 Bitmaps (bytemaps)

Consider the letter H for display on an alphanumeric VDT. Its bitmap has, for example, the form:

```
0 0 0 0 0 0 0 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
0 0 1 1 1 1 1 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
0 0 1 0 0 0 1 0
```

8 × 10 bits

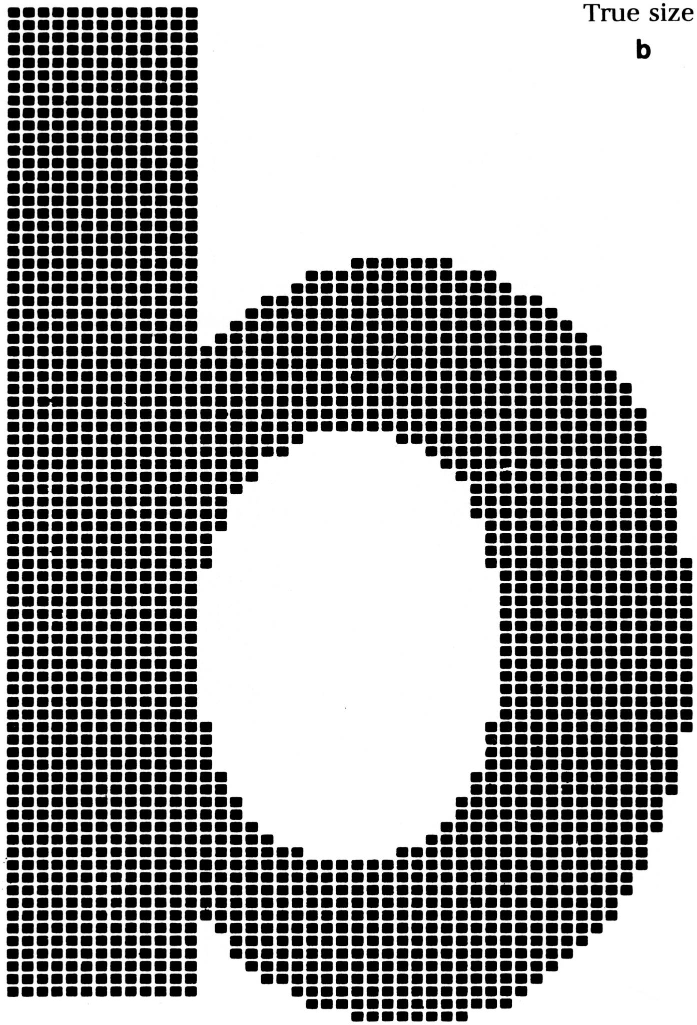


It would therefore seem obvious to store the 80 bits in 10 bytes and scan the bitmap from left to right horizontally, line by line from top to bottom. When doing so it is not important whether one sets the zeros equal to black and the ones equal to white or vice versa (video reverse).

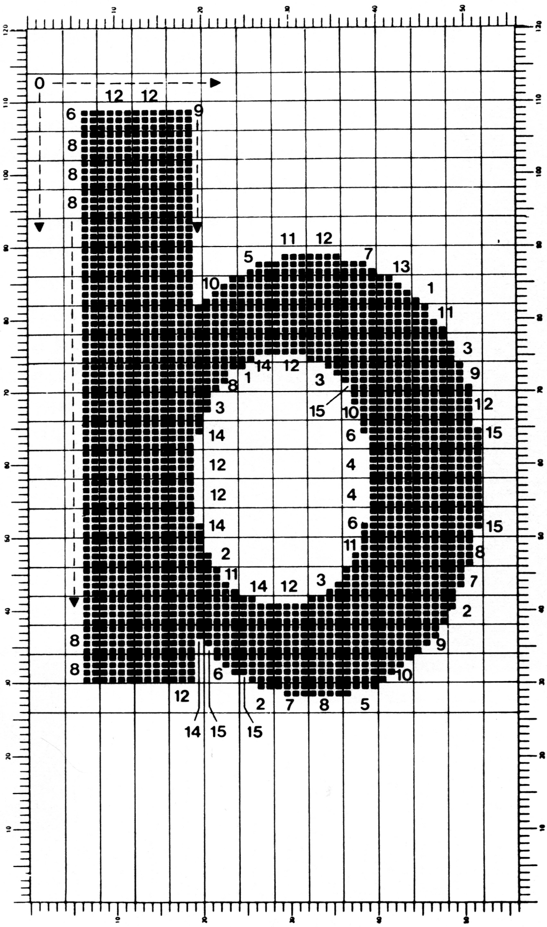
The format of a typeface which is to be typeset monospaced on an alphanumeric VDT (first generation) is thus extremely simple:

Every 10 bytes a new character starts. If the device can only display 128 characters, one needs a 1280 byte memory and the addresses for the image information are basically "ASCII value times 10".

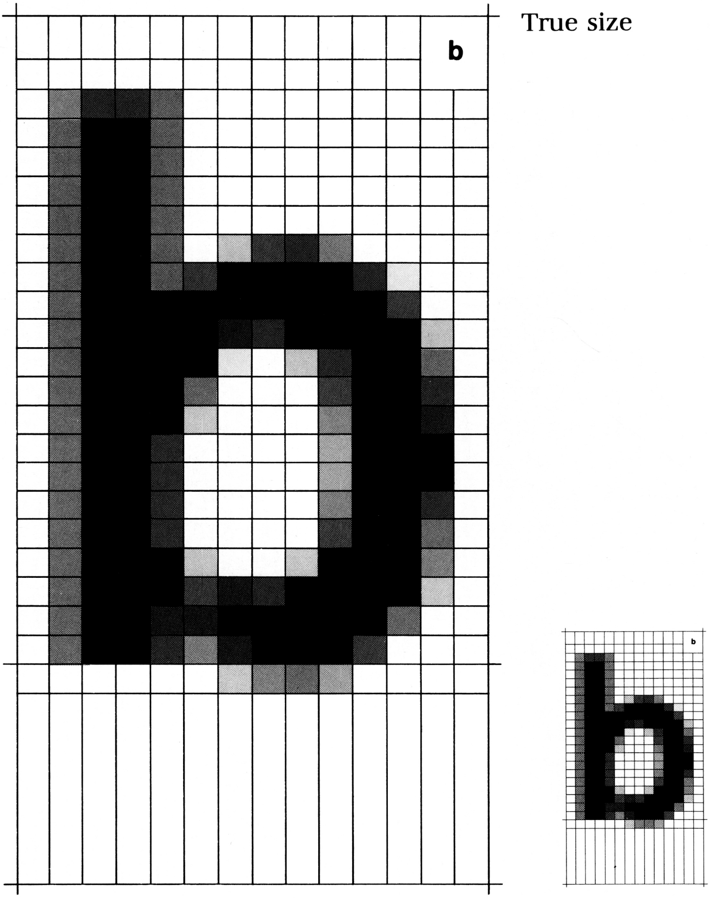
With newer display terminals (second generation) and for TV captions one needs bytemaps instead of bitmaps. Depending upon the number of halftones at the edge between black and white, one may have quarterbytes (4 steps), halfbytes (16 steps) and bytes (256 steps). To transform a bitmap into a halfbytemap, 4 × 4 bits for example, are brought together, counted out and stored. There is, however, one limitation: 15 and 16 bits both produce a halfbyte of the highest value 15 (see also the following diagrams). The transformation of halfbytes back into their original bits is not possible (see lit. Warnock).



Bitmap of lower case b at a raster of 100 × 120 for the em.


0
12
12
6
9
8
8
8
11
12
5
7
13
10
1
11
3
14
12
8
1
3
9
3
15
10
12
14
6
15
12
4
12
4
14
6
15
2
11
8
11
14
12
3
7
2
8
9
8
6
10
12
2
7
8
5
14
15
15

Preparation and calculation of a bytemap
at a raster of 25 × 30 for the em.

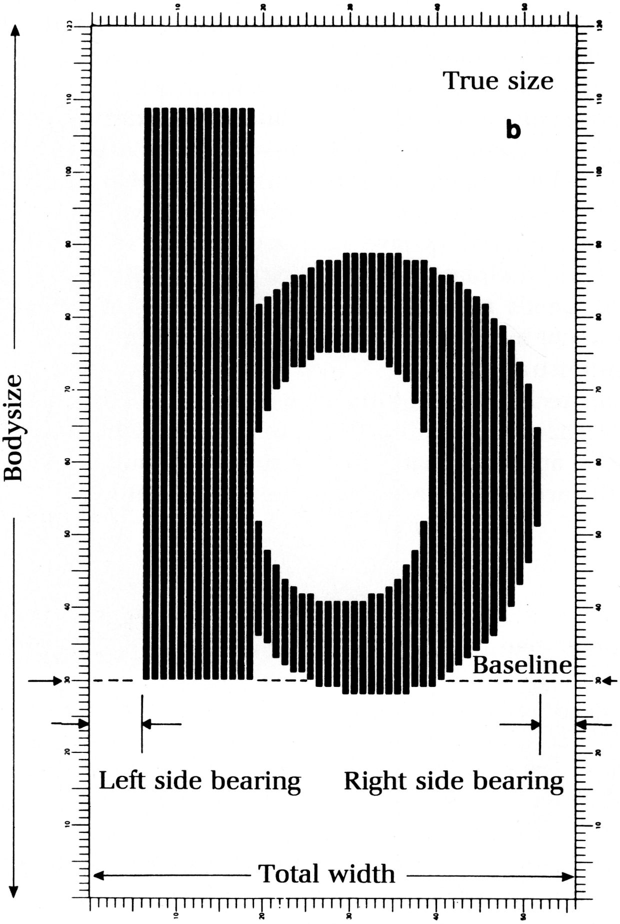

b
True size
b

Bytemap of a lower case b
at a raster of 25 × 30 for the em.

5.1.2 Run lengths

Bitmaps and run length codes are basically not very different. As bitmaps get larger and larger the question gradually arises of whether one should consider the successive zeros and ones in one line, i.e. count them out and code their number as a run length. When displaying letters by either horizontal or vertical lines (columns or rows) in a raster there are black and white alternations. With run length coding one assumes that the line starts externally to the letter and the first segment of the line thus always starts in white. Then black and white change at the transitions and one need not get involved in a special color coding for black or white.

On average, Latin letters have 3.5 transitions per scanline passing the em and fill approximately 43% of the em width. Thus, for a 32×32 bit raster one needs approximately $32 \times 0.43 \times 3.5 \cong 48$ bytes per letter plus $14+6=20$ bytes for the organization and handling of the scanlines (administration data), i.e. a total of 68 bytes. On the other hand the bitmap technique requires $14 \times 4 = 56$ bytes ($14 =$ average thickness of 32×32) not including the data required for administration. It is very soon apparent that from the above resolution levels upwards run lengths are a shorter form of coding than bitmaps.


True size
b
Bodysize
Baseline
Left side bearing
Right side bearing
Total width

Run length of lower case b
at a raster of 100 × 120 for the em.

5.1.3 Open vectors

Transitions in neighbouring lines have a linear relationship in the first approximation.
Let us consider "H" in Helvetica:

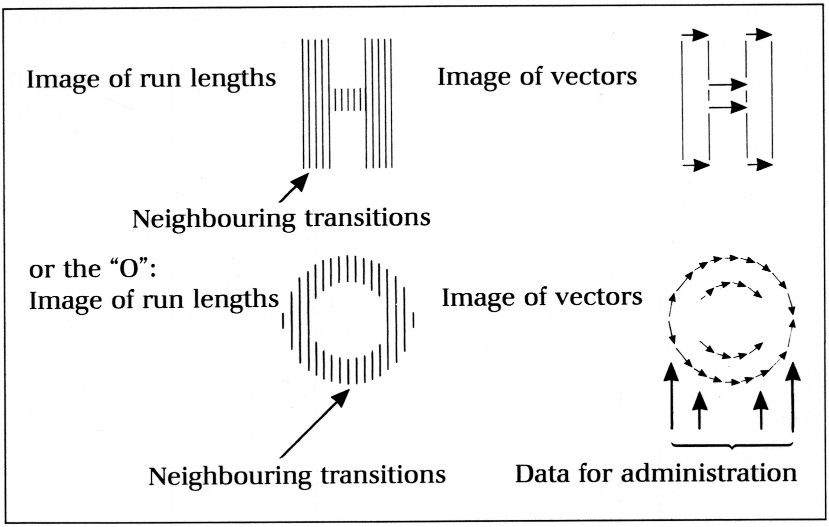
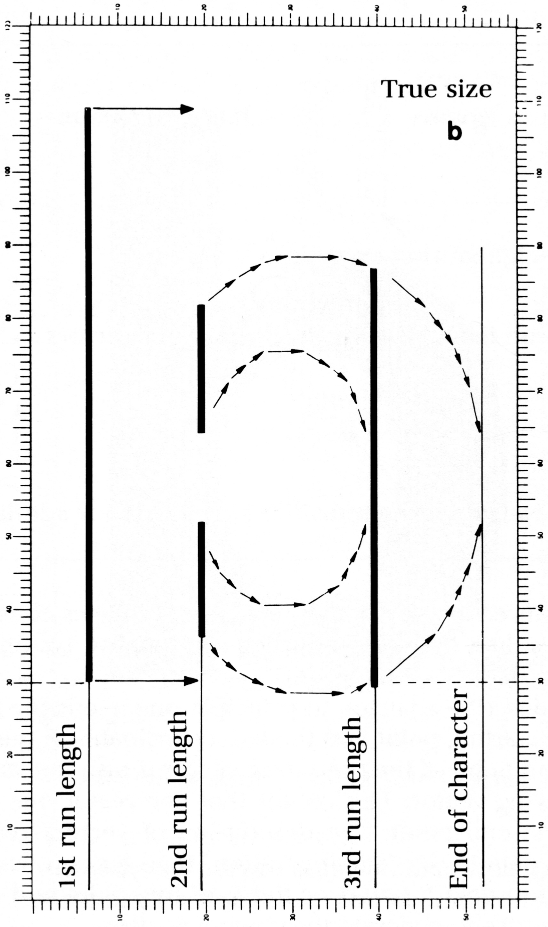


Image of run lengths
Image of vectors
Neighbouring transitions
or the "O":
Image of run lengths
Image of vectors
Neighbouring transitions
Data for administration

It is hardly necessary to mention that vector images consist of fewer straight lines than the corresponding run lengths, i.e. one therefore requires less data.
In order to describe a vector, in principle one needs the two coordinates of the starting point and the two coordinates of the end point. Often the end point of the preceding vector is also the starting point of the following vector. This means that per vector one only needs details of the end point. The description of vectors requires relatively more data in the "administration" than for run length coding, i.e. description data for start or finish of line pairs and also a little more electronics to generate the control signals.
Vectors are also used to generate letters for direct VDTs (graphic VDTs of the first generation), microfilming devices and plotters. Whereas before the vectors represented the edge of the black surfaces, here the vectors represent the middle of the basic strokes.


True size
b
1st run length
2nd run length
3rd run length
End of character
10
20
30
40
50
60
70
80
90
100
110
120

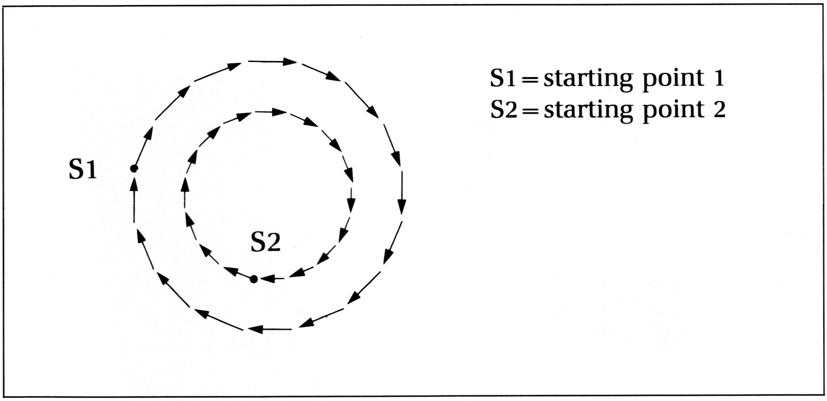
Open vector format of lower case b
at a raster of 100 × 120 for the em.

5.1.4 Closed vectors

Once data has been stored in the open vector format a great deal of electronic effort is required to make them rotatable. Up till now no manufacturer has actually managed this using the open vector format.

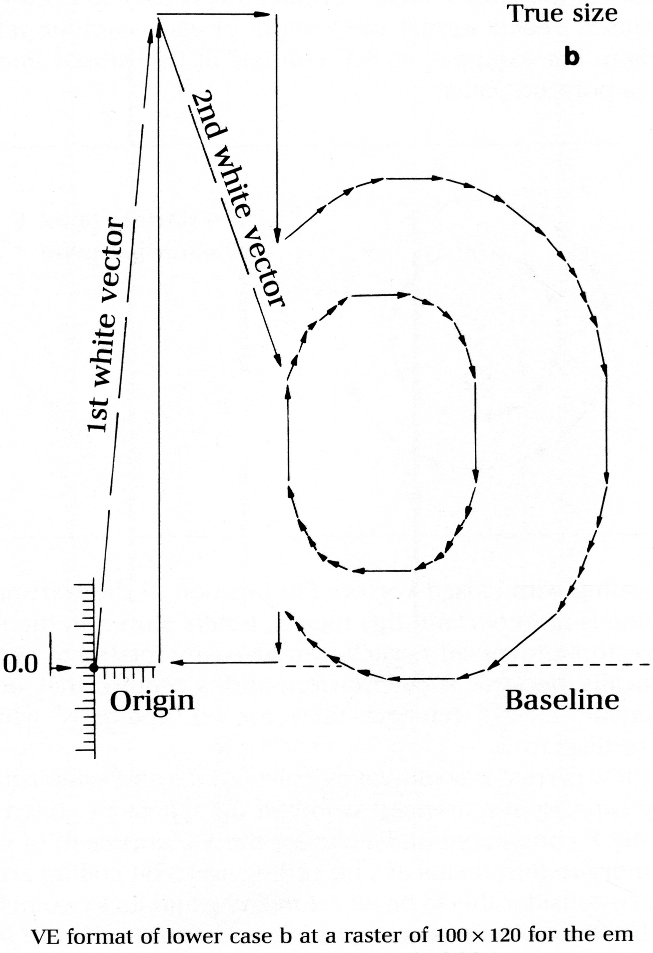
In the case of the closed vector formats this is easy to achieve:

In the closed vector format the vectors of each contour return to their origin. For example, an "O" consists of two closed line-paths, known as polygon paths:



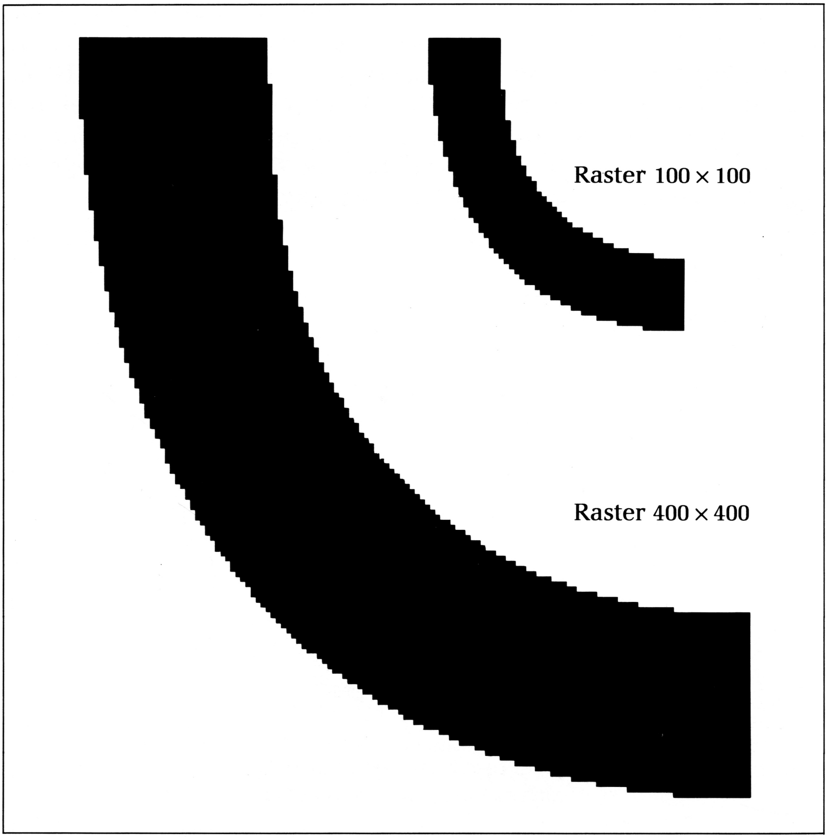
When dealing with closed vectors the position of the starting point for the line is unimportant; this means, letters stored in the form of closed vectors processed as such, can be easily rotated or deformed electronically because such transformations require that only the characteristic "closed" remains; there are no "openings" which are rotated or displaced.

In 1982 URW carried out simulating calculations and established that memory capacity requirement is lowest for typefaces coded with 4 bits for the X component and 4 bits for the Y component of vectors. The memory requirements of 3 bit coding and 5 bit coding are much higher. We consider this to be an astonishing and lucky coincidence, since 8 bit (2 × 4 bits for one vector) is an important figure in computers. URW uses a special code for the sign change in X or Y directions and also a special code for very long straights.


True size
b
2nd white vector
1st white vector
0.0
Origin
Baseline

VE format of lower case b at a raster of 100 × 120 for the em (each coarser raster is calculable).

On the other hand the 4 bits are not so astounding because with 4 bits one is able, without too much effort, to code vector lengths between 1 and 13 (14 and 15 are reserved for special coding).
When considering bitmaps for different rasters between 100 × 100 and 400 × 400 per em, one sees that irrespective of the fineness of the raster at curves, hardly any vector components occur which are longer than 13.
Disregarding long straight lines, which are given a relatively long special coding, curves represent more than 90% of the total codes required!



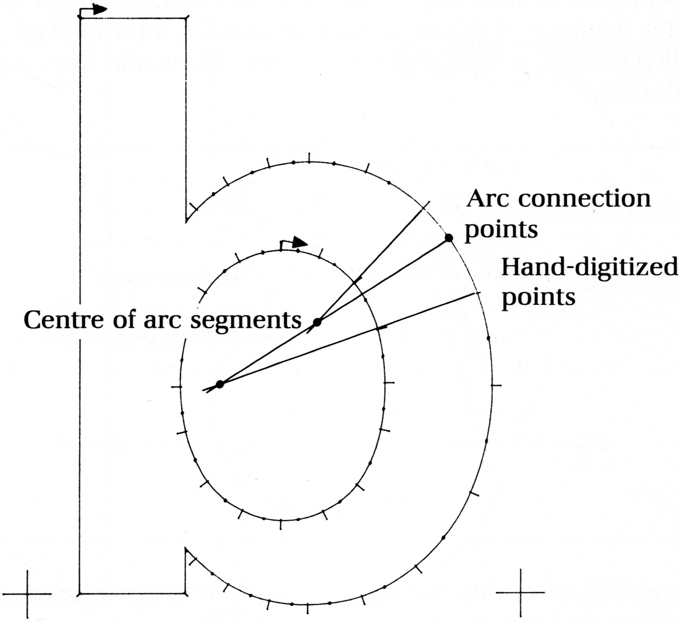
5.1.5 Curved lines

Curved lines is a slightly inelegant term which we use to distinguish all non-linear outlines. Curved lines is taken by us to be a description which may include elements such as:

- Straights and circles (Bitstream, URW),
- Bézier functions (Adobe),
- Spirals (Purdy, AM, Itek),
- Splines (XEROX and others).

Straights/circles

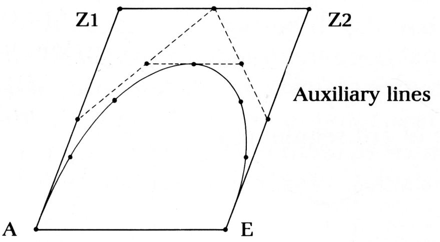
URW uses this format directly for drawing machines and graphic displays, other firms use this format for high resolution typesetting machines (60 to 100 lines/mm). It can be developed most directly and rapidly from the IKARUS format as mentioned later in this book. Basically, straight lines are used to link corners with each other and with tangent points, where we have a tangential transition of straights into curves. The curves are described as segments of circles which all blend into one another tangentially (see also 6.3).


Arc connection points
Hand-digitized points
Centre of arc segments

DI format of lower case b at a raster of 15,000 × 15,000 for the em. The combination of IKARUS and DI format is Bitstream format (each coarser raster is calculable).

Bézier functions

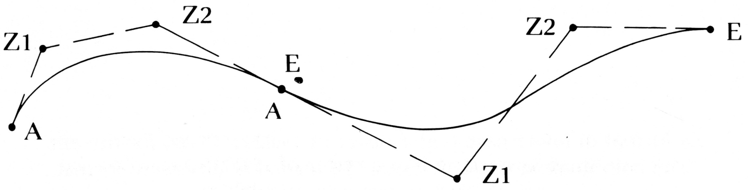
Readers are no doubt familiar for the most part with straights and circles, but not necessarily with Bézier functions. The Bézier function runs between specified digitizations which are never reached, except for the start and final point. Mathematically it is similar to the spline function (a third degree polynom as mentioned later on).
Take, for example, 4 points, 1 starting point, 2 intermediate points (so-called control points) and 1 end point. We would then arrive at the following:

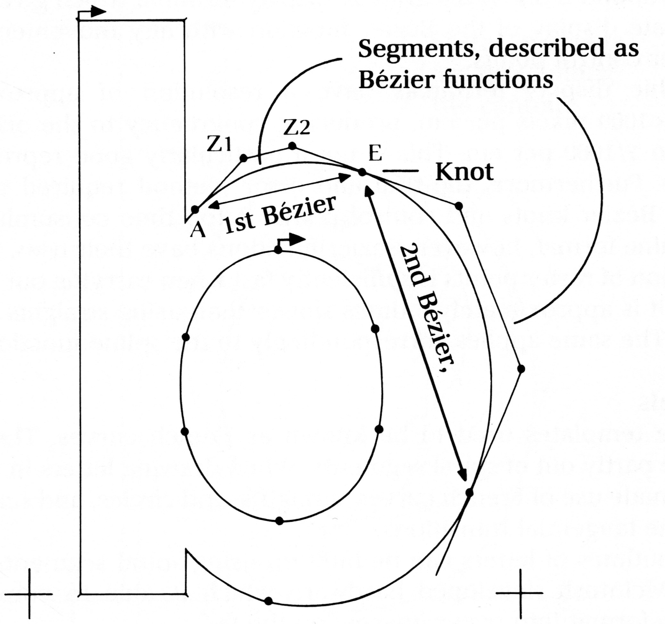


$$B(x,y) = A(x,y) \times (1-t)^3 + Z_1(x,y) \times (1-t)^2 \times t + Z_2(x,y) \times (1-t) \times t^2 + E(x,y) \times t^3$$
$$t = 0,\ldots,1$$

Bézier function

We have marked in thin the auxiliary lines in order to demonstrate the position and construction of the Bézier line.
We have also included more figures below in order to illustrate the effect of the Bézier function.




Segments, described as Bézier functions
Z1
Z2
E
Knot
A
1st Bézier
2nd Bézier,

Adobe format of lower case b at a raster of 15,000 × 15,000 for the em (each coarser raster is calculable).

In our opinion only automatically generated Bézier knots are of any usefulness. As far as hand digitization is concerned this method appears to us to be unsuitable, as it is a great deal more time consuming than for example the digitization using the IKARUS format. Bézier control points are located outside the outline and can only be easily found if one has a graphic display terminal which gives an immediate display of the Bézier function with any movement of the Bézier control points.

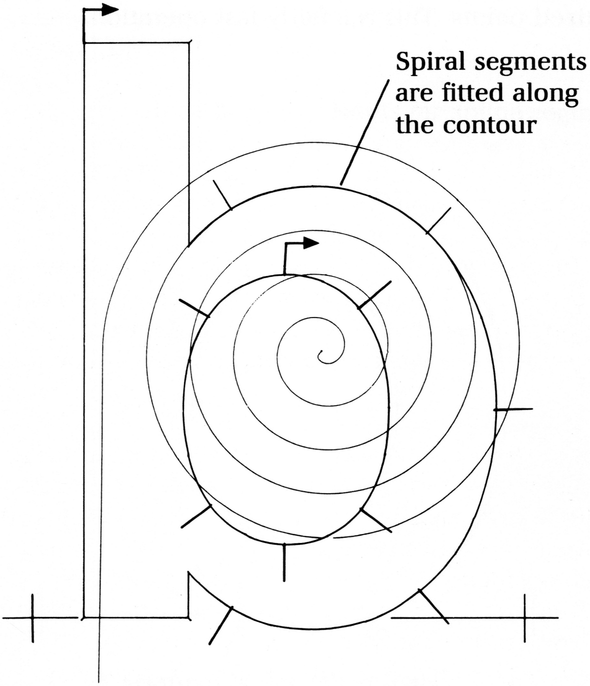
Graphic display terminals have a resolution of approximately 1000 × 1000 pixels per em, producing congruency to the original to within 1/1000 per em. This is not a particularly good reproduction value. Furthermore, the trial and error method required to select good Bézier knots and control points is too time consuming. As a machine format, however, Bézier functions have their uses. The calculation of raster points is sufficiently fast when carrying out typesetting. It is approximately 6 times slower than using straights and circles. The same applies correspondingly to the spline function.

Spirals

Curve templates used to be known as French curves. They were made partly out of spiral segments. When drawing letters in the past one made use of French curves, straights, and circles, and scraped to get the tangential transitions.

The outlines of letters can be built up using spiral segments. Purdy and McIntosh developed hardware which is able to convert the Purdy format into raster images “on the fly”.

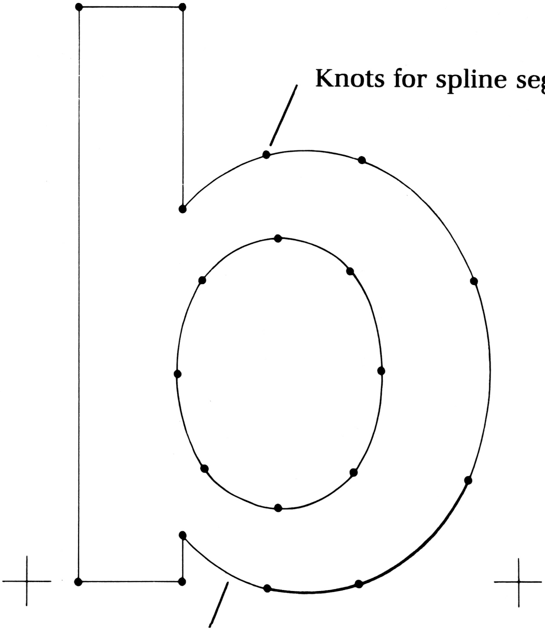
Unfortunately however, the digitization – i.e. data input – is too time-consuming and has a resolution lower than 1/1000 per em. On average one needs about 15 minutes interactive work on the screen to fit the spiral segments to the letter. In comparison, the average marking time per letter is only 2.6 minutes using the IKARUS format plus 2.6 minutes pure digitization time. We do not consider the Purdy format to be absolutely suited to data basing. It is difficult to edit and not very easily transformed or distorted.


Spiral segments are fitted along the contour

Purdy format of lower case b at a raster of 4000 × 4000 for the em (each coarser raster is calculable).

Splines

A spline function for the representation of letters is a very good attempt in the right direction. We have used this method since 1972, but have also dropped it to some extent. Put another way, of the spline interpolation for IKARUS points we only use the tangents of the digitized points. This is a fairly fast operation.



Knots for spline segments

A segment is described with

$x(t) = a_x + b_x \cdot t + c_x \cdot t^2 + d_x \cdot t^3$

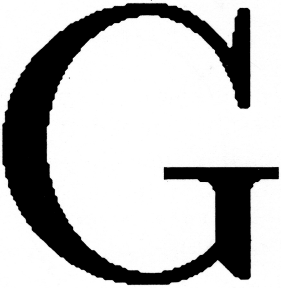
$y(t) = a_y + b_y \cdot t + c_y \cdot t^2 + d_y \cdot t^3$

$t =$ line distance

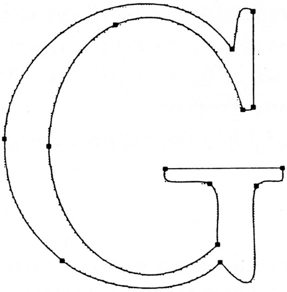
$\{a_x \ldots d_y\}$ are constant for a segment

Spline format of lower case b at a raster of 15,000 × 15,000 for the em.
The scanned knots are at a raster of 1000 × 1000 for the em
(each coarser raster is calculable).

To show this in more detail the figure below is an example of the spline method for letters as used by XEROX (ref. Stone). It is apparent that an automatic digitization is a good starting point; it would be very difficult and also time-consuming if the knots were to be found manually, guided by eye. However, this format has disadvantages: it cannot be edited by displacement of knots and is therefore not transformable.
The automatic digitization of letterforms within this format cannot follow the original more precisely than the scanning accuracy (i.e. approximately 1/1000 per em width).



Scanned original



Result of spline fit

5.2 Other concepts

A short history of previous concepts for the preparation of digital types has been edited at the Stanford University (ref. Ruggles). A concept is assessed in this study according to its performance in the field of artificial generation of new letters, or rather, the degree of complexity thought up by the respective inventors.

Whilst not wishing to overlook the fact that such criteria are possibilities for assessment, we should not ignore the fact that the major criterion has been omitted.

There are very many typefaces available for all imaginable purposes. The main consideration is to place these faces into digital formats. Thus the most important criteria today are:

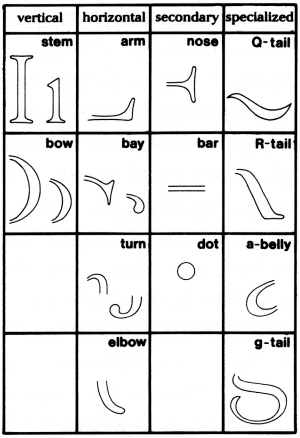
- speed of data acquisition
- quality of storage (accuracy, adaptability into machine formats).

The computer aided generation of new types should be considered as of secondary importance. We question whether a designer using a computer would be faster than using conventional methods.

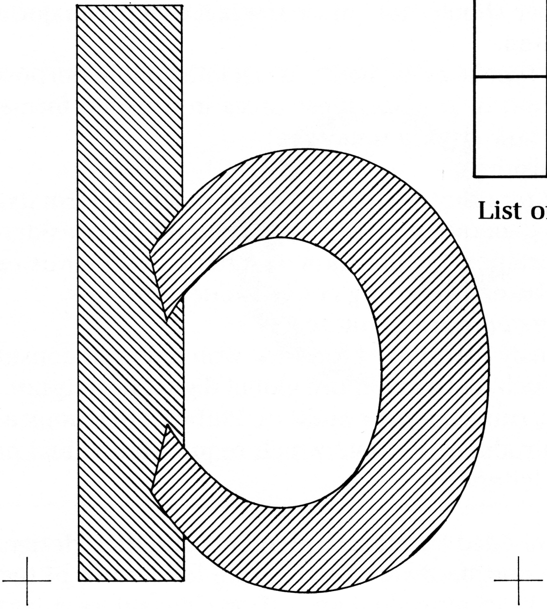
At least two other concepts are of interest:

In contrast to previously considered formats, which do not consider individual letters as such, but use a more global digital description of a font as either pixels, run lengths or outlines, Philip Coueignoux and Donald Knuth have produced formats which require individual programs for individual letters.

Philip Coueignoux divided letters into elements and then designed appropriate software and hardware to generate letters out of these elements. The exact type reproduction – if one considers a larger cross section of types – does, however, leave something to be desired. The advantages of the Coueignoux format are in the low storage requirement.


vertical
horizontal
secondary
specialized
stem
arm
nose
Q-tail
bow
bay
bar
R-tail
turn
dot
a-belly
elbow
g-tail

List of typical elements

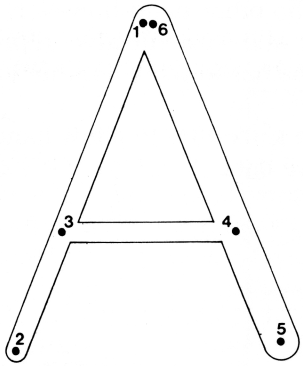


1st element for b,d,h,k,l(t,)
2nd element for b,p

The Coueignoux format consists of elements of a typeface
and of individual software to combine them to form characters.

Donald Knuth created the Metafont concept. This is very well suited to varying a Metafont type. The modification possibilities are virtually infinite. On the other hand however, Metafont is not very well suited for exact and cost-effective reproduction of existing types. Furthermore, one has to write a rather long program for each individual character.

Steps have been made since 1983 to allow hand-digitized data to be also used as descriptive data.



```
% The letter A
%
%---------------------------------------------------------------
% specify where output goes
drawdisplay;                       % draw letter on screen
proofmode;                         % print proof sheet
%---------------------------------------------------------------
charcode 'A;                       % this is a capital A
%---------------------------------------------------------------
% position the points
x1=98;  y1=250;                    % x and y coordinates for each of
x2=0;   y2=0;                      % 6 points
x3=40;  y3=90;
x4=170; y4=y3;
x5-105; y5=y1;
x6=203; y6=5;
%---------------------------------------------------------------
% specify the pen
cpen;                              % circular pen nib
%---------------------------------------------------------------
% draw the charcter                % using a pen width of 15, draw a line
15 draw 1..2;                      % between points 1 and 2, and between
   draw 3..4;                      % points 3 and 4; then with a pen
25 draw 5..6;                      % of with 25, draw a line between
                                   % points 5 and 6.
end
```

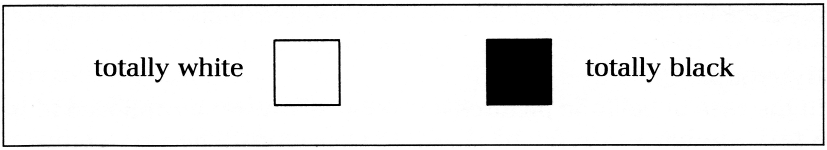
The Metafont program for an upper case A.
All raster resolutions are programmable
(each coarser raster is calculable).

5.3 Special coding techniques

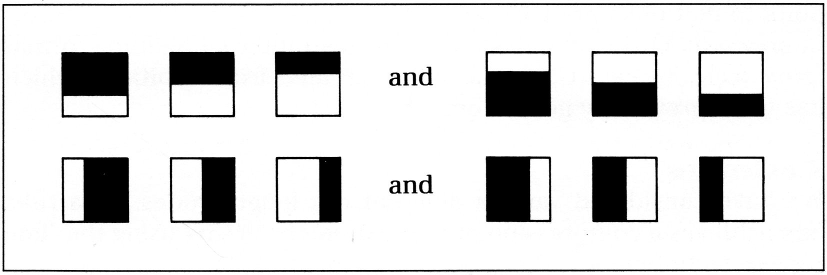
Over the last twelve years a lot of special coding techniques have been developed, some are described in the following section.

Bitmaps

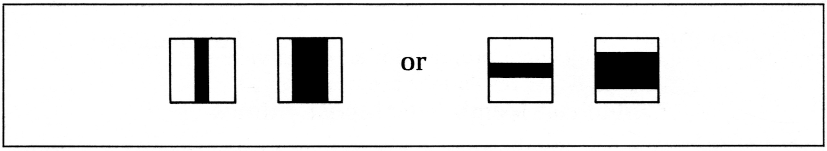
Bitmaps could also be coded in “block encoding” (ref. Knudson). For example for 4 × 4 bits, it is not necessary to have 16 bit data, because many of the 256 combinations do not appear within the black and white image of a letter.We definitely have the elements:



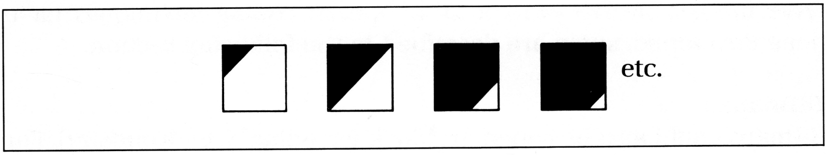
and the element groups:



If one has enough information on stroke thickness one could perhaps exclude thin lines such as:



A similar argument applies to diagonals which perhaps only appear in the following forms:



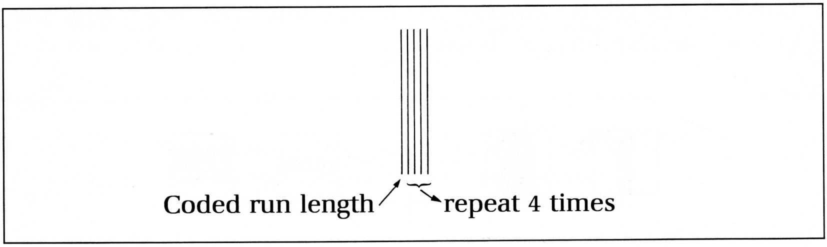
One can almost sense that the reproduction of letters can very well be achieved with only $2^8 = 256$ possibilities, i.e. a reduction of the storage capacity necessitated by a factor of 2. In appendix P we describe our own internal bitmap format (BI format).

Bytemaps

In the case of halftone pictures it is relatively rare – as opposed to in a text – to have extreme black/white transitions. The very compact storage of halftone pictures as used in telecommunication makes use of this fact and uses an average of 2 bits per grey pixel (normally 8 bits), in order to code the relative colour tone change of one image point to that of its predecessor.
In appendix Q we have described our own internal halftone format (grey scale format = GS format). It is created from a bitmap which has to be previously generated.

Run lengths

We have considered various different run length codes. As a rule, one achieves a compression of approximately 30% by using the "line repeat" technique.An "I" e.g.:



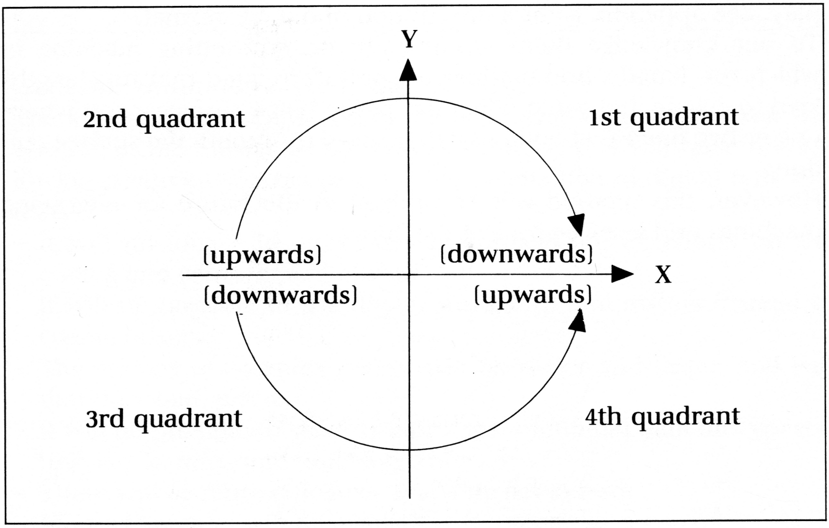
Other methods of reducing memory requirements are to search for the largest occurring run length in letters or in the type for a prescribed raster. This allows the n-bit-byte to be calculated, allowing the largest run length to be coded, and also all smaller run lengths to be coded, incrementally. Incremental means having data not of the absolute position of the transition, but rather of the respective lengths of the black or white line segments. In appendix N we describe our own internal run length format (scanline format=SC format).

Vector formats

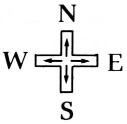
Open vector formats are available which run in small steps from edge point to edge point. This coding is known as nibble coding. As far as we are concerned there are two possibilities which are economical:

a) 1-bit-nibbles 0 straight in X direction →
1 straight and vertical skip. ↗

This requires super-imposed coding of the appropriate quadrant, e.g. when describing a circle. For certain quadrants "1" can only mean "upwards", for others it can mean "downwards".



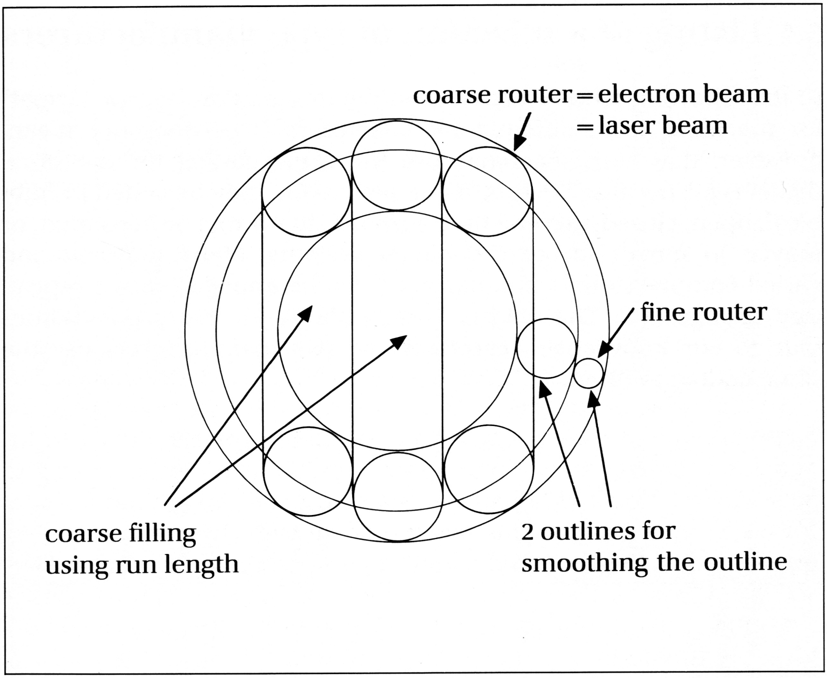
b) 2-bit-nibbles 0 ≙ north
1 ≙ west
2 ≙ south
3 ≙ east



Using this code one can, for instance, completely describe circles or spirals. This coding is very compact, and allows segments to be accessed by addressing (with pointers from/to).
See appendix M for a description of our internal vector format (VE format).

Complex outlines and run lengths

We expect future developments to produce a large number of machines which can directly handle and process complex outlines. Some are already in existence. In a technique corresponding to the vector format one can code straights as before, and circles incrementally. For segments of circles one states the end point with a vector plus the chord length. This has the advantage that one avoids the problem of coding large radii, and 3 bytes per circle segment are sufficient. However, the output of the chord height requires greater computer capacity for the regeneration of the circle data in the display. See appendix K for a description of our VC format.
To our knowledge there is currently no typesetting machine in which run lengths and outlines are so interrelated that run lengths lead to coarse, but rapid filling out of the black surfaces, and where one or two fine exact outlines can be used to smooth the surface outlines.
However, this method will be utilized in the future for engraving machines and laser engraving machines.


coarse router = electron beam
= laser beam
fine router
coarse filling
using run length
2 outlines for
smoothing the outline

General comments

The cost of data storage and of the electronic equipment itself will also fall in the future. To our way of thinking this will have the following positive consequences for the production of digital type formats:

- It will no longer be necessary to concentrate all efforts on the coding and compression of data.
- It will be possible to use digital storage of fine rasters instead of coarse rasters.
- The storage of complex curves will be easier and faster, and will therefore take place.
- It will be possible to store and process additional data for typesetting, e.g. kerning and touching tables.
- There will be more typefaces available per system.
- More characters will be available per typeface.

5.4 Listing of a selection of type manufacturers

In the following table we have used the designation “vector format” for machines from different manufacturers. This does not mean, however, that such machines use the same coding for the same digital type, because vectors, as we have seen, may be coded in “nibbles”, open, closed, incremental, absolute, in normal or in rotated, or maybe in mirror image coordinate systems. Many different and varied compression techniques may also be applied (vector repeat, sign change etc). The field of coding allows so many possibilities that, to our knowledge, regrettably no two manufacturers use the same coding method.

Company	Country	Machine/ product	System used	Kind of data base	Kind of machine format
Adobe	USA	software, RIPs	own	hand-digitized, IKARUS data	curved lines, bitmaps
AGFA	Belgium	laser printers	own/IKARUS	hand-digitized	bitmaps
Alphatype	USA	CRT machines	own	scan data	open vector format
AM	USA	CRT machines	Purdy	scan data	Purdy format
Ampex	USA	image makeup	own	scan/Edit	halftone
Apple	USA	laserwriters	Mac	bitmap	bitmap
ARISTO	Germany	drafting tables	–	–	curved lines
Artronics	USA	image makeup	–	–	halftone
ATEX	USA	front ends	own/IKARUS	outline	outline
Autologic	USA	CRT machines	own/IKARUS	scan data/hand-digitized	curves, nibbles
BBC	UK	TV	own/IKARUS	IKARUS data	halftone
Berthold	Germany	various setting machines	IKARUS	hand-digitized	curved lines, vectorlines
Bigelow & Holmes	USA	typefaces	IKARUS	hand-digitized	all formats
Bitstream	USA	typefaces	LIP, Toolbox	hand-digitized	Bitstream format, bitmaps
Bobst	Switzerland	see Autologic			
Böger	Germany	see Scangraphic			
Chelgraph	UK	RIPs, laser setting machines	own	outline	vector data, cambray
CGK	Germany	laser setting machines	own/IKARUS	hand-digitized	curved lines
Compugraphic	USA	various setting machines	Intelefont/IKARUS	hand-digitized	vector format, curved lines
Crosfield	UK	page makeup	–	–	–
Dainippon Screen	Japan	page pakeup	–	–	–
Gerber	USA	signmakers	own	hand-digitized	vector format
Harris	USA	setting systems	own	scan data	run lengths
Hell	Germany	page makeup, setting machines, filmrecorders	SCRIPTUS	scan data/hand-digitized	curved lines, run lengths, halftone
Hewlett Packard	USA	laser printers	Symbolics	hand-digitized	bitmaps
Honeywell Bull	France	laser printers	own	–	bitmaps
HTS	USA	setting systems	–	–	–
IBM	USA	laser printers	own	scan data	bitmaps
III	USA	CRT machines	own/IKARUS	scan data/hand-digitized	run lengths, vector lines
Imagen	USA	laser printers, RIPs	own	scan data	bitmaps
ITC	USA	typefaces	–	hand-digitized, IKARUS data	analog
Itek	USA	CRT machines	own	scan data/edit	vector format
Letraset	UK	transfer letters	IKARUS	hand-digitized	analog
Letterphot	Germany	photosetting machines	analog	–	analog
Linotype	Germany	setting machines	own/IKARUS	scan data/hand-digitized	vector formats, run lengths, curved lines
Mergenthaler	USA	see Linotype			
MGD	USA	see III			
Microtype	France	typefaces	IKARUS	hand-digitized	all formats
Monotype	UK	setting machines	own	scan data	run lengths
Morisawa	Japan	setting machines	own/IKARUS	scan data, hand-digitized	run lengths, vector format
Moskau I	USSR	–	IKARUS	hand-digitized	–
Moskau II	USSR	–	IKARUS	hand-digitized	–
NEC	Japan	various printers	own/IKARUS	hand-digitized	bitmaps
NIC	Japan	RIPs	own/IKARUS	scan data/outline	vector formats
OCE	Netherlands	laser printers	own	bitmaps	bitmaps
Okura	Japan	setting machines	own/IKARUS	scan data/hand-digitized	curved lines, run lengths
Olympia	Germany	laser printers	own/IKARUS	bitmaps	bitmaps
Philips	Netherlands	laser printers	own	bitmaps	bitmaps
PMT	Japan	CRT machines	own/IKARUS	hand-digitized	vector format
Purup	Denmark	laser setting machines	own	hand-digitized, IKARUS data	vector data
QMS	USA	laser printers	own	bitmaps	bitmaps
Quantel	UK	image makeup	own	hand-digitized, IKARUS data	halftone
Qume	USA	laser printers	own/IKARUS	IKARUS data	bitmaps
Ryobi	Japan	setting machines	own/IKARUS	hand-digitized	curved lines
Scangraphic	Germany	CRT machines	own	scan data	run lengths
Scitex	Israel	page makeup	own	hand-digitized	Bitstream format
Sha-ken	Japan	setting machines	own/IKARUS	scan data/hand-digitized	vector data
Siemens	Germany	laser printers	own	IKARUS data	bitmaps, run lengths
SIMX	Norway	image makeup	own	hand-digitized	run lengths
Signus Ltd.	UK	typefaces	IKARUS	hand-digitized	all formats
Stempel	Germany	see Linotype			
Tektronix	USA	VDTs	–	–	vector data
Typoart	DDR	typefaces	IKARUS	hand-digitized	run lengths
URW	Germany	typefaces	IKARUS	hand-digitized	all formats
Versatec	USA	electrostatic printers	–	–	vector data, bitmaps
Visual Graphics	USA	photosetting machines	analog	–	analog
Wild	Switzerland	drafting tables	–	–	curved lines
XEROX	USA	laser printers	own	scan data/hand-digitized	bitmaps

6. The URW concept

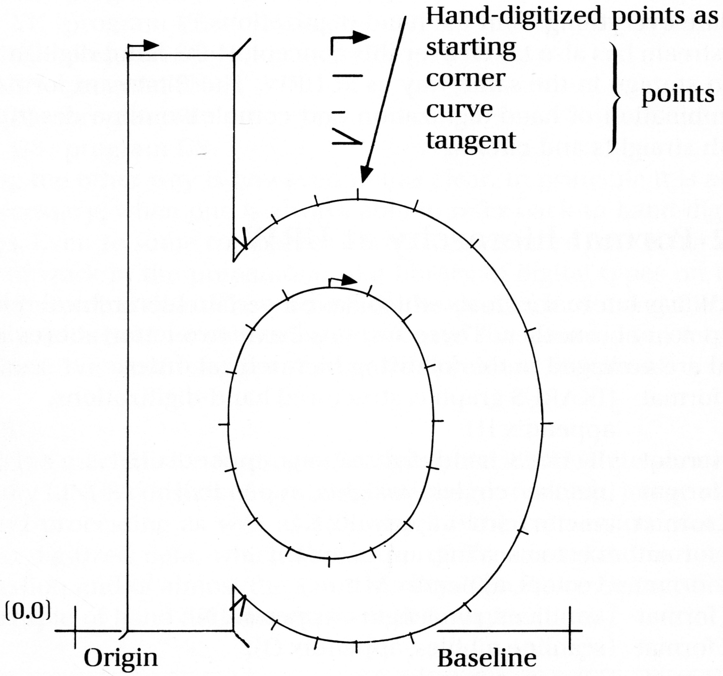
The backbone of the IKARUS concept is the storage of hand-digitizations from which one can then calculate all machine formats. This concept – storage of hand-digitizations – is currently used by the manufacturers of typesetting machines.

6.1 IKARUS

Most digital formats used to date have served the purpose of allowing a certain machine to display letters. The faster and more powerful the microelectronics of the machine become, the more complex one may make the format.

But if one considers only the machine, one might make the mistake of forgetting the digital form itself.

The true digital form is hand-digitization. It can be carried out very accurately and quickly, approximately 2.6 minutes per letter with a 1/100 mm accuracy for a cap height of 10 cm. This means the em raster is 15,000 × 15,000 pixels. This is possible not only for very good black and white artwork, but also allows the use of pencil sketches or bad copies: it allows the human brain to smooth out any roughness of original lines or edges when digitizing, and thereby guide the positioning of the digitizations. In appendix X we have written down rules for marking, and in appendix Y rules for the digitization of letters.


Hand-digitized points as
starting
corner
curve
tangent
points
(0.0)
Origin
Baseline

IKARUS format of lower case b
at a raster of 15,000 × 15,000 for the em
(each coarser resolution is calculable).

These digitizations specify the run of letter outlines. This is why these digitizations represent the most important, non-transient digital data, because they form the data basis (for description of the related IK format see appendix I). One only has to be sure that this hand-digitized information allows all other digital formats to be derived. This has been no problem to date, we have been able to calculate everything from the hand-digitizations.

Bitstream has also taken over this concept. Here, hand-digitization is also storage in the same way as at URW. The Bitstream format is a combination of hand-digitization and complex outline descriptions with straights and circles.

6.2 Format hierarchy at URW

URW has internal formats which have a certain hierarchical relationship to one another. These formats have two-letter abbreviations and are arranged in the following hierarchical order:

IG format	(IKARUS graphic, structured hand-digitizations, appendix H);
IK format	(IKARUS, hand-digitizations, appendix I);
DI format	(display, circles/straights, appendix J);
VC format	(vector/circle, appendix K);
VS format	(vector/scaling, appendix L);
VE format	(vectors, appendix M);
SC format	(scanlines, run lengths, appendix N);
SN format	(scanline nibbles, appendix O);
BI format	(bitmap, appendix P);
GS format	(grayscale, bytemap, appendix Q).

In the appendices we have detailed formats which are in part written in a non-compressed form. We have done this in order to allow the respective data users to prepare their own compression and safety encryption to match their own electronics from the transferred data.

On the other hand, we have so far been able to use our own non-compressed formats to calculate all existing digital machine formats, e.g. the special vector format for the client from the internal VE format. As a rule this conversion (programming the post processor) takes between one day and six weeks work (on average: two weeks).

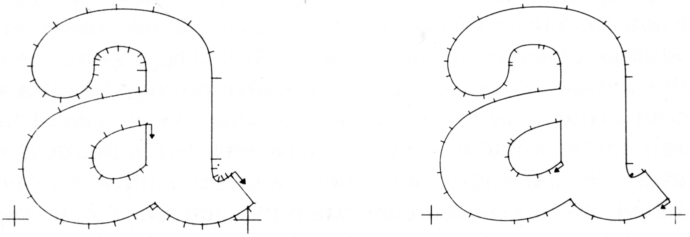
It is undoubtedly possible to reach a deeper hierarchy step using programmed versions. At URW such programs exist for the conversion of:

IK → DI program DI
IK → VC program VC
IK → VS program VS
IK → VE program VE
DI → SC program SC
DI → SN program SN
SC → BI program BI
BI → GS program GS

Moving the other way is however, not as clear. In principle it is also not necessary, when one is always able to refer back to hand-digitizations. Even so some companies have invested more than 100 man-years of work in the preparation of a library of digital types on the basis of scanline data. They now face the problem of using this to create a data base in outline form to cover the demands of future machines. We would suggest solving this problem as follows:

LINUS

LINUS is a machine for reading or scanning black and white pictures. Basically LINUS consists of hardware for image scanning, image storage and processing as well as software for the conversion of scan data to digitized data, which should be of the same kind as hand-digitization and of almost the same quality. The figure below shows an example of hand and automatic outline digitization.



Hand-digitized Automatically digitized using scan data

At URW this reverse conversion (VE→IK) took a great deal of effort (from 1979 to 1984). Other reverse conversions have, however, been appreciably easier to program:

DI → IK no problem
SC → VE no problem
BI → SC no problem
GS → BI is not possible, but then again not required.

Inherent in the hierarchy, and fundamental in the URW philosophy, is that the IK format has a digital precision which is greater than that required by the typesetting machine. Letters in IK format are stored in a raster of 15,000 × 15,000 per em. This has the advantage that when preparing coarser rasters there is no interference between the stored raster and the target raster.

The finest raster required by typesetting machines is 2500 × 2500 per em, for good typesetting machines an average of 400 × 400, and for all other machines still coarser. The resolution of our storage raster is thus usually by a factor of 10 finer, which means that for example, both a 400 × 400 raster as well as a 401 × 401 raster can be calculated to the same quality.

The 400 lines may be precisely placed on the IKARUS raster with approximately a 1/40 line separation, in the same way the 401 with a slightly lower separation, namely:

at 400 with 15,000/400 = 37.5
at 401 with 15,000/401 = 37.4

The line separation resulting is:

37, 38, 37, 38, 37, 38, 37, 38, ...
and 37, 38, 37, 38, 37, 37, 38, 37, 38, ...,
as counted in IKARUS fine raster points.

This is what we mean when we say: “There is no interference between storage raster and target raster”. The picture would be different if the storage raster were only 800 × 800 per em. The 400 × 400 raster would present no problem by accessing every second line. The line separation would be 2 everywhere, counted in points of the storage raster. The 401 × 401 raster would not be so simple, however; we would have 398 times a line separation of 2 and twice a line separation of 1, counted in storage raster points. One either has to take two sequential lines out of the 800 once, or one would have to continuously interpolate a new line between two lines in correlation to their real position between these lines. Both methods produce mistakes! The very fine resolution of the IKARUS data avoids this and is a good solution to the problem – and no mistakes!

In addition to the degree of fineness of the digitized data according to the "digitized once and for all" mode, it is extremely important that the hand-digitizations themselves are stored. Only in this way can one carry out subsequent manipulations upon the data easily, like moving a single point (corrections) or calculating a sphere projection (typesetting on a globe).

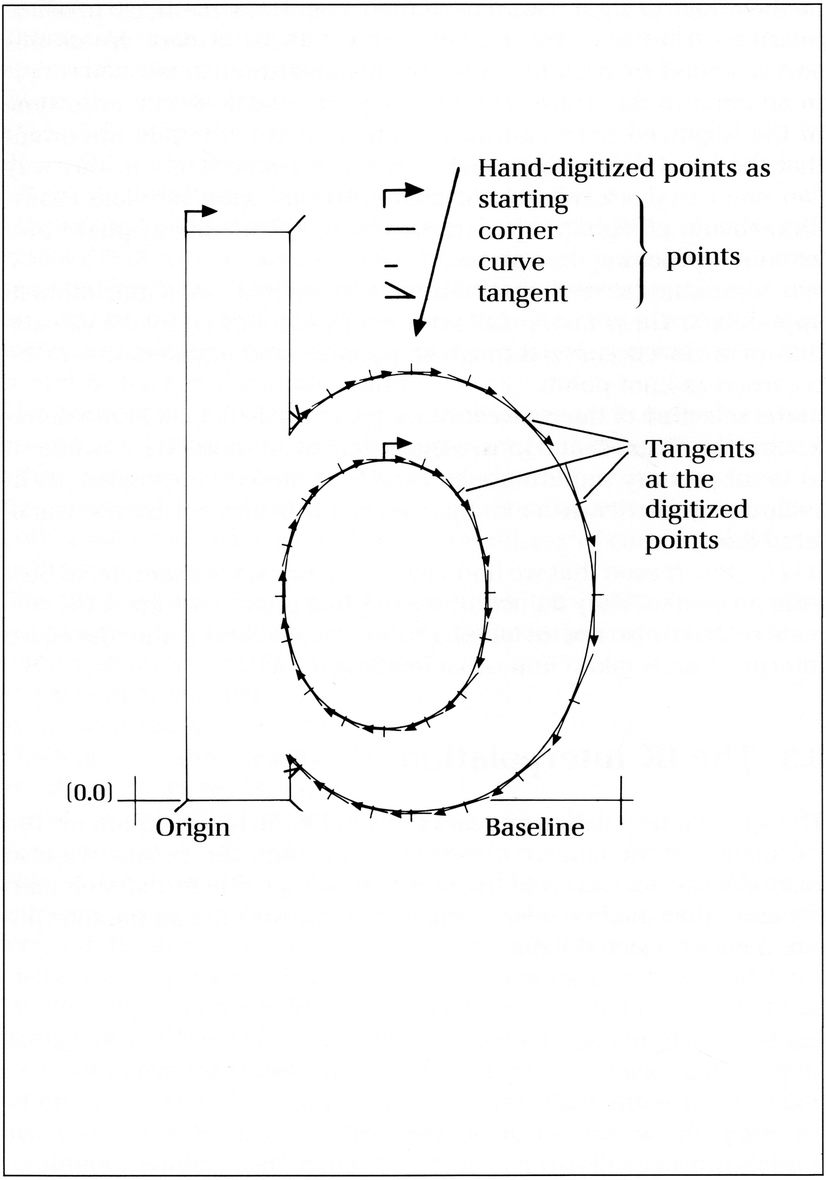
We have summarized the manner and method of digitization in appendix X. These manipulations are always followed by the calculation of a closed curve through the given hand-digitizations, to be regarded as knot points.

In the selection of this procedure we spent a great deal of time determining the cleanest and most elegant technical route. We consider it to be of primary importance to carry out the curve calculations in such a way that each hand-digitized point is also hit by the calculated line.

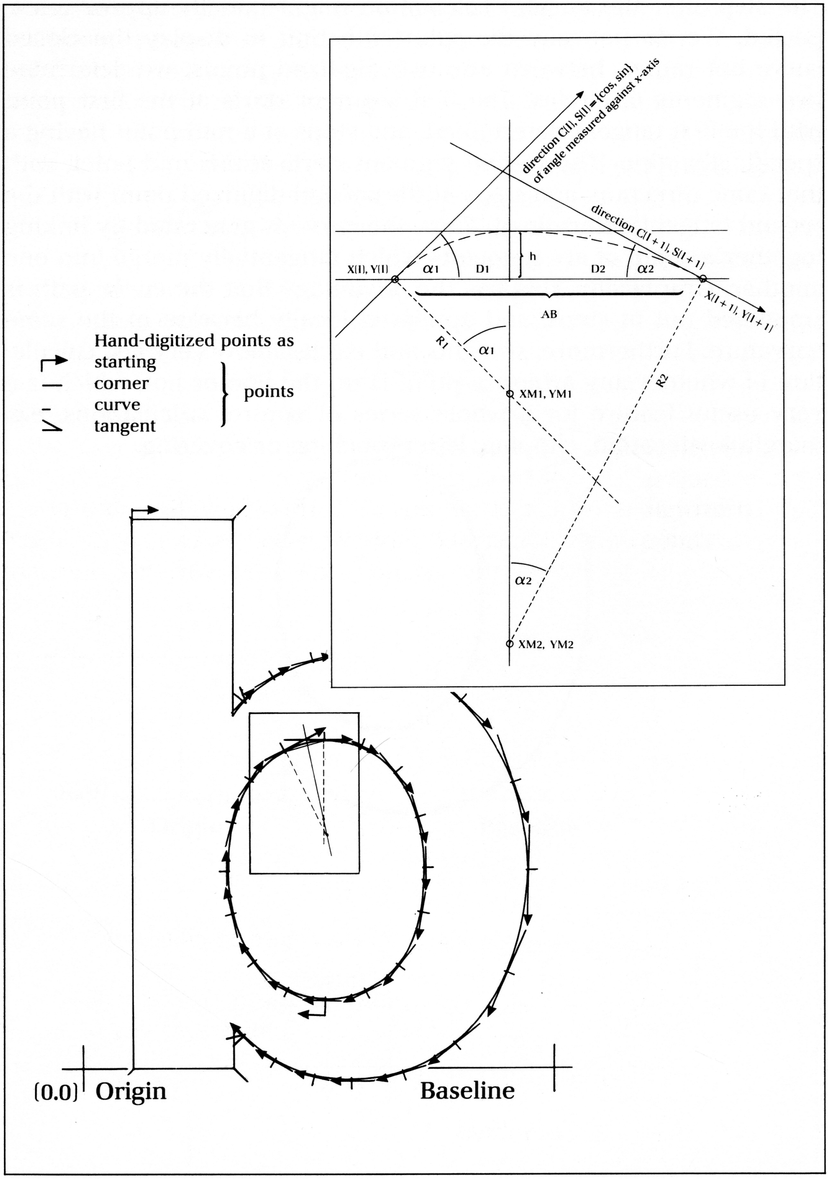
It is for this reason that we find Bézier functions, for example, to be a little off course. They do not hit the original points. For the same reasons we have also not included a curve fit calculation, only the curve interpolation is taken into consideration.

6.3. The IK interpolation

The spline interpolation appears to us to be the best solution for the calculation of the tangent directions of the digitized points. We also carried out calculations of the tangents using circle fitting, polynom fits and other methods, we compared them with the spline interpolation – and rejected them.


Hand-digitized points as
starting
corner
curve
tangent
points
Tangents at the digitized points
(0.0)
Origin
Baseline

The step after the tangent calculation might initially appear unexpected. We do not take the spline function to display the closed curve but rather, between any two digitized points, we determine two segments of circles. The first segment starts at the first point with the first tangent determined, and stops at a mid-point having a specific direction. The second segment starts at this mid-point, with that same direction, and stops at the second digitized point with the second tangent determined. Thus, the curve is generated by linking together a chain of arc segments which tangentially merge into one another. Graphically, this has the advantage that the curve path is smoothed out in steps, and appeased locally because of the same curvature. Furthermore, straights and circles allow very fast calculation of whether any arbitrary point is on the line or not, which is a very useful feature for a whole series of control calculations, e.g. margin justification, clipping, letter touching or covering.

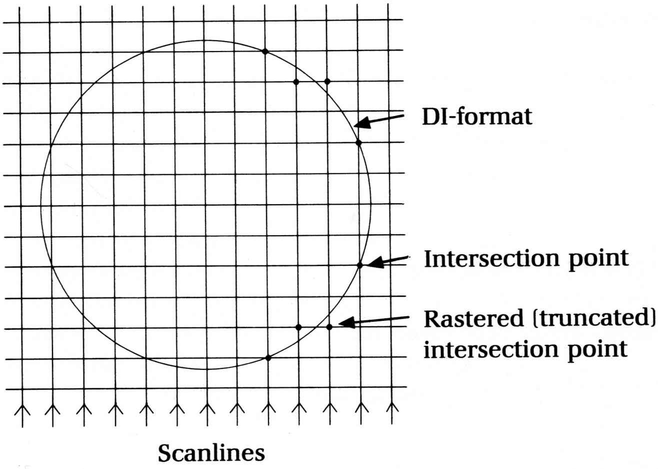

direction C(I), S(I) = (cos, sin) of angle measured against x-axis
direction C(I + 1), S(I + 1)
X(I), Y(I)
α1
D1
h
D2
α2
X(I + 1), Y(I + 1)
AB
R1
α1
XM1, YM1
R2
α2
XM2, YM2
Hand-digitized points as
starting
corner
curve
tangent
points
(0.0)
Origin
Baseline

Furthermore, this method does not produce undesirable changes of curvature which have to be excluded by the inclusion of damping terms when using spline functions. When using damping terms, however, it is not necessarily easy to convert the outline description during the typesetting on the fly into control signals for the letter output. Straights and circles on the other hand present no problems in this case. Electronic modules are available which, aided by a DDA (Digital Differential Analyzer), are capable of a rapid conversion of straights and circles into pixels.

The circle parameters can be more quickly calculated than the 8 coefficients of the spline functions between two digitizations. We have included the appropriate programs in appendix W, written in FORTRAN.

The result of these curve calculations is known as the DI format (display format). It can be used directly in graphic displays, in some typesetting machines and on all NC machines.

The DI format is the basis for the SC format (scanline format). A raster is placed under that closed representation and a program then searches for intersection points of the raster lines with the DI format (see sketch).



This method is known as soft-scanning as opposed to hard-scanning with scanners.
Soft-scanning has enormous advantages compared with hard-scanning:

- It runs on the computer without any manual work.
- It doesn't scan dirt marks or other original inadequacies like ragged edges.
- The pattern (here the IK format) is adjusted automatically to be rectangular to the scan direction.
- Errors at black and white edges caused by electronic noise can always be avoided.

So much time can be saved using the automatic method of soft-scanning for the preparation of good rastered types that the time requirement for the hand-digitizing is more than compensated for.

7. The preparation of rasters

We have already pointed out that open vector formats, run length codes or bitmaps are only special descriptions for what which is normally understood as digital type, i.e. a letter presented in certain raster form.

This statement also applies ultimately to all formats which use curved lines to describe digitization. Except that in this case the resolution is so fine (in the case of our DI format: 15,000 × 15,000 per em), it is no longer the raster itself, but only general details, e.g. cap height, thickness or accuracy of analog reproduction (machine cutting) which need to be discussed (see point 3.3).

At URW the generation of such scanline rasters is known as the preparation of SC formats. The raster size per em can be selected arbitrarily. However, we have already seen that a 10 × 8 raster really is the lower limit, and a 1600 × 1600 raster per em presents a very fine resolution. Video display units or matrix printers work with 2 or 3 lines/mm, the better typesetting machines with 100 lines/mm. In this case, a raster with 1600 × 1600 per em would mean a body size of 16 mm = 42.7pt = "display of headlines in text". One can of course, create rasters with different separations between X scanlines and Y scanlines.

At URW the SC format is prepared in two steps. Firstly automatic soft-scanning and secondly any possible residual work required by interactive corrections on a graphic display. We deliberately say "possible residual work" because most soft-scanned letters do not require any correction.

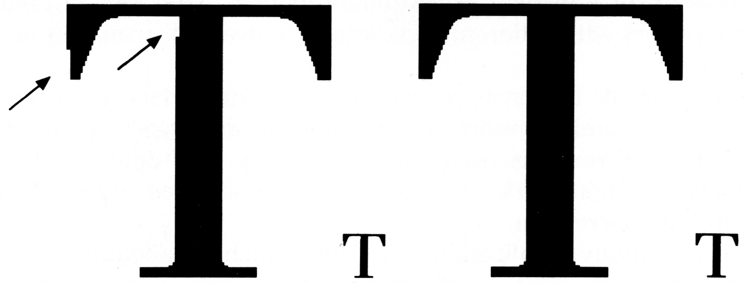
There are many applications in which such corrections are not needed anyway. There have indeed been cases where rastered types have been introduced on the market which were the direct result of hard-scanning with all marks, contaminations and flaws caused by the electronic noise and using "normal" artwork.

7.1 Soft-scanning

At URW soft-scanning is a fairly established procedure which has developed over the years and has shown itself to be correct.
We first of all had to recognize that the fine DI format may be regarded as thin lines lying across a usually coarser raster. This hardly affects the overall rastering, provided that small adjustments are made to define DI lines. We have programmed the corrections and achieved the following effects – automatically:

Channel processing
The “channelling” program sets almost vertical and almost horizontal straight lines exactly vertical or exactly horizontal. The effect is that these lines are reproduced in the rastered form without raster skips. The program also takes the following matters into account:

- All curves with slight curvature, e.g. the flutes of a serif, are not treated by the channelling.
- Diagonals or slightly sloped straights are not affected.



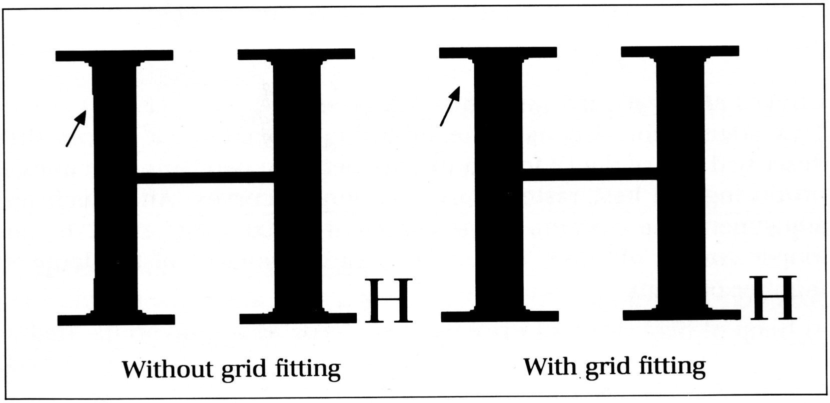
Without channel processing With channel processing

Grid fitting of straight stems and crossbars
The program “PA” for “grid fitting” takes stems of approximately the same thickness, but which through the rastering would come out with slightly non-uniform thicknesses, and fits the same number of

raster lines. The fitting should not, as far as possible, change the appearance of the original, and a modification or change of weight should not occur.

The program takes the following matters into account:

- Straight stems with ductus changes e.g. “Optima” type, are not affected.
- The fitting is carried out for raster sizes of up to approx. 400 × 400 per em. Finer rastering no longer requires such a detailed treatment.
  Diagonals are not treated.

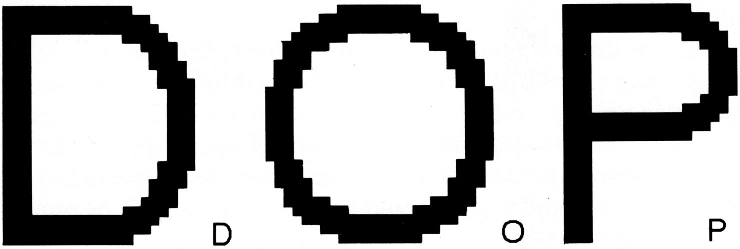


Without grid fitting With grid fitting

Thickness of horizontal and vertical curve strokes

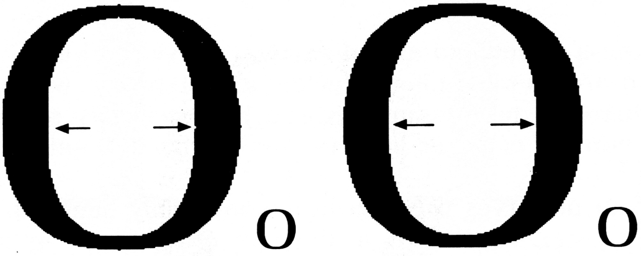
Curved strokes with uniform thickness in a typeface, which rastering has altered to be non-uniform, can be specifically refitted to the same number of raster lines in their horizontal and vertical segments.

The path of curves can also be automatically adjusted to a prescribed raster. Particularly in the case of light type in small type sizes, a large number of inconsistencies would otherwise crop up in the uniform parallel path of curved strokes.



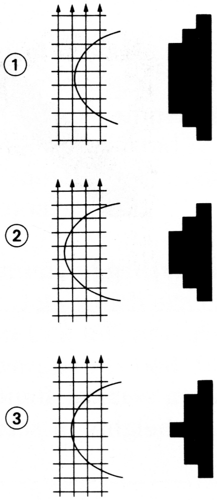
With grid-fitting of straights and curves

Curves at 0°, 90°, 180°, and 270° (degrees)
This adjustment also uses the following procedure: it places the described line of the DI format exactly between two "soft-scan lines", producing the best raster representation of curves. After such an adjustment, the extrema of the curves at 0°, 90°, 180° and 270° no longer consist of either only a few raster points or of too large a number of them.



Without curve fitting With curve fitting

In the following sketches we have attempted to show this effect as clearly as possible:



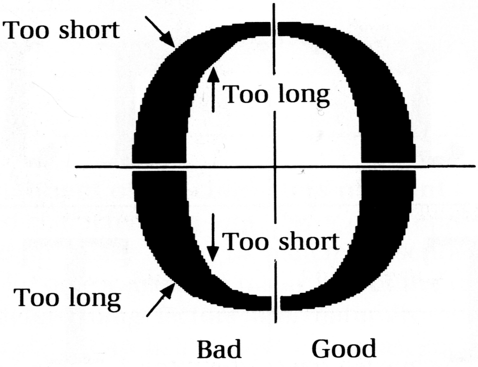
① Curved line just behind scanline, badly programmed

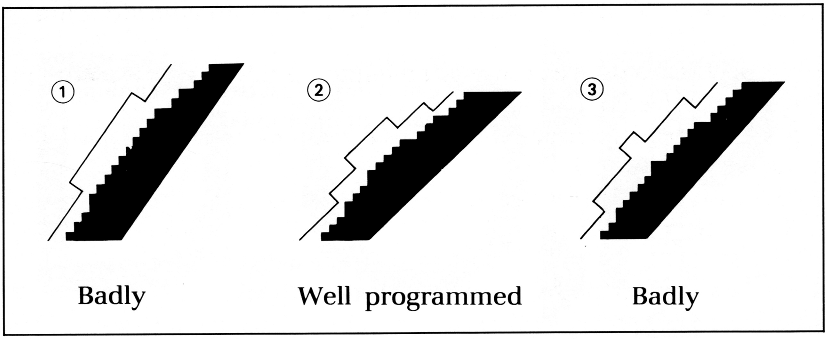
② Curved line between scanlines, well programmed

③ Curved line just over scanline, badly programmed

Curves at 45°, 135°, 225° and 315°

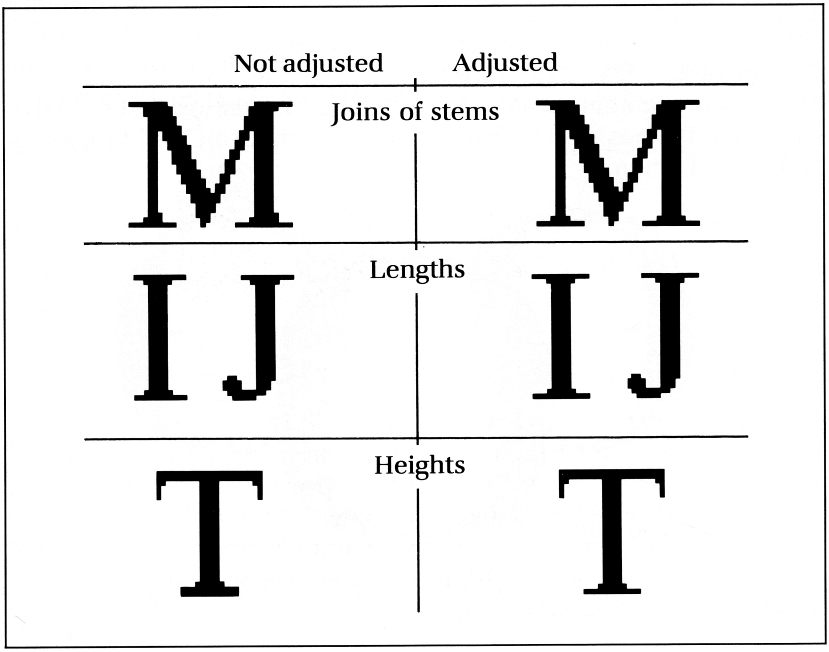
The curved segments at 45°, 135°, 225° and 315° are treated similarly, where an obvious step structure may form that can lead to good or bad reproduction.


Too short
Too long
Too short
Too long
Bad
Good


①
②
③
Badly
Well programmed
Badly

Treatment of serifs

- The joins of the curves of horizontal serifs to vertical stems of a face are made uniform and the lengths and heights of serifs are equalized, where required.

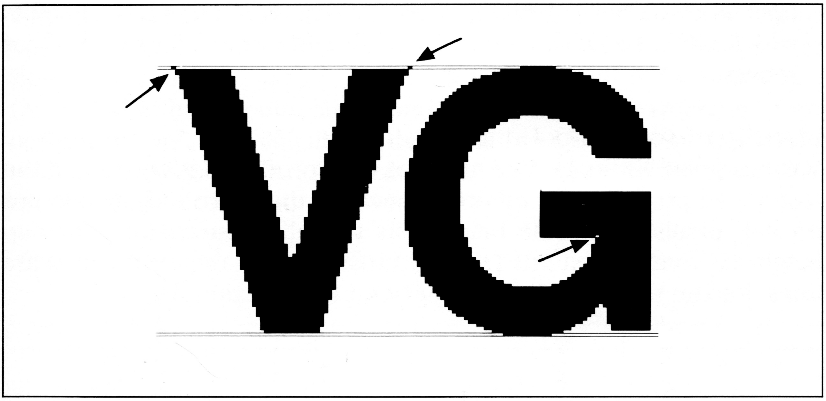

Not adjusted
Adjusted
Joins of stems
M
M
Lengths
IJ
IJ
Heights
T
T

The following situations must always be taken into consideration:

- Vertical serifs such as those to be found on the E cannot automatically be adjusted.
- Serifs, whose upper or lower edges are not parallel to the base line cannot be adjusted.
- The same considerations apply of course to those serifs found on diagonal stems.

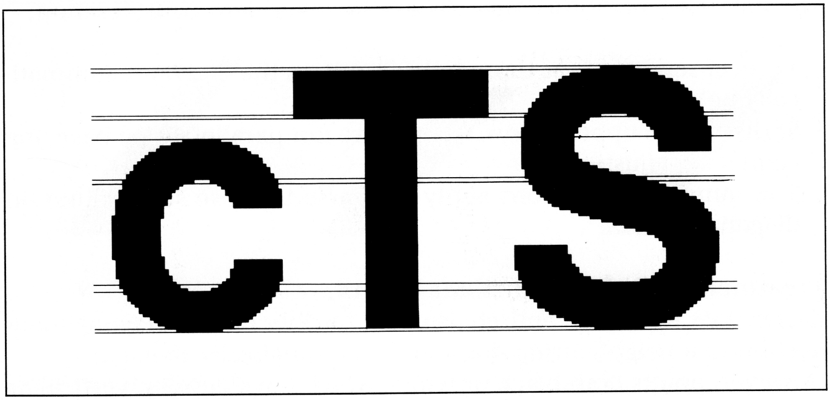
Treatment of individual raster points

Raster dots which are entirely isolated or only have a diagonal connection to a neighbouring dot may be automatically deleted. However, points both black or white, which have either a vertical or horizontal connection with another point are not automatically deleted.



Height adjustment of the characters of a font

The standard characters of a font (lower case, upper case, numerals) are adjusted in raster steps to match prescribed auxiliary lines. These lines lie on a calculated raster line of the respective scanline step. The determining factors are, naturally enough, descender, baseline, x-height, cap height, lower case ascender height and the respective overhangs of curves.



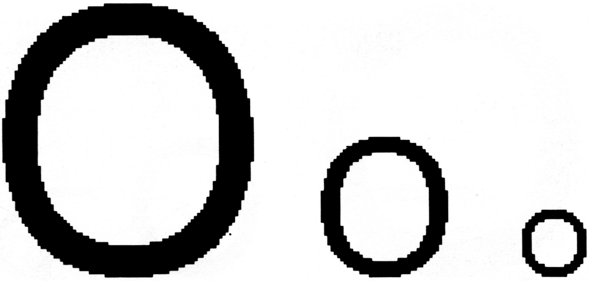
One should realize that:

- The more exotic the face the less it should be adjusted.
- Special characters or punctuation marks sometimes have heights which well exceed the normal, and should not be adjusted for that reason.

Identity of various point sizes

Various point sizes of a face may not be reproduced identically if the raster size proves to be different, because there are only whole but no half pixels. The table below lists guideline parameters for cap height (H), vertical stems (X) and crossbars (Y) measured in scan-lines, for the rastering in 32pt, 16pt and 8pt as examples:

	32pt	16pt	8pt
H	84	42	21
X	11	6	3
Y	10	5	3

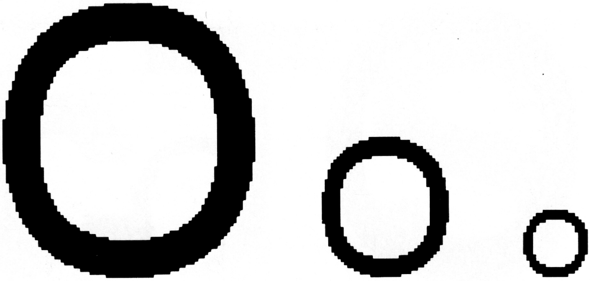


Rasters of the letter "O" in 32pt, 16pt, and 8pt.

Since in the case of letters in 32pt not all sizes are even, the 16pt size is not produced by simple halving. The 8pt version has also to be changed because when halving uneven numbers of scanlines either up or down it will not exactly match the 32pt version or the 16pt version. In fact, in the case in question it will turn out to be bolder.
On the other hand, point sizes can be matched when working " from bottom to top". One calculates the parameter for the smallest point size and increases by multiplication. In our example the parameter lists for this would be as follows:

	32pt	16pt	8pt
H	84	42	21
X	12	6	3
Y	12	6	3

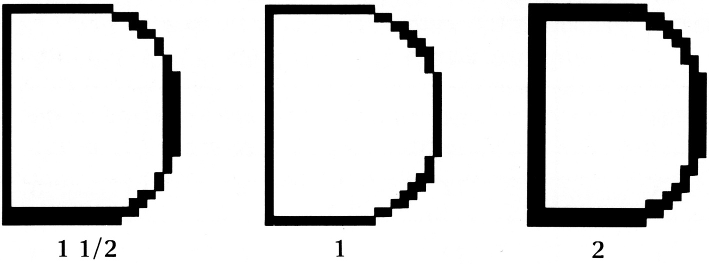
The result now shows greater deviations from the original. The heights, stem thicknesses etc. are, however, consistent in all three point sizes.



Rasters of the letter "O" in 32pt, 16pt, and 8pt.

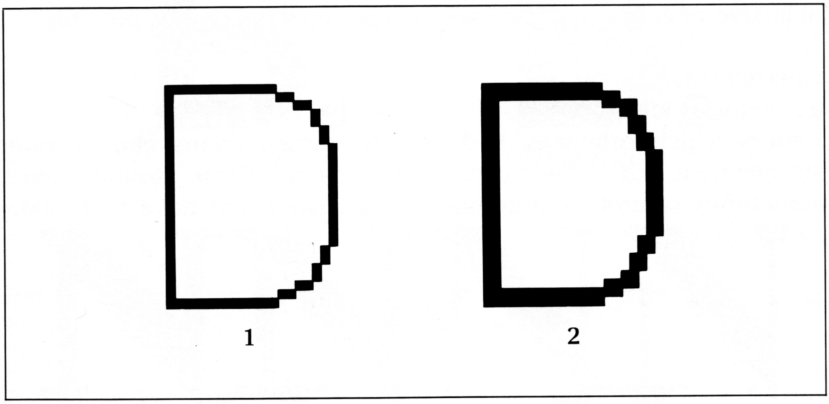
Disputable cases

The following example demonstrates how a non-adjusted letter with 1.5 pixel stroke width can be adjusted to two different stem thicknesses. In the first case one scanline was used, in the second case, two scanlines to give the corresponding stem parameters to the grid fitting procedure.



1 1/2 = without fitting
1 = with grid fitting of stroke width to one pixel
2 = with grid fitting of stroke width to two pixels.

All three results are unsatisfactory, soft-scanning alone is no help. One has to use the outline program beforehand to either carry out a thinning to one line (inner outline), or thicken up to two lines (outer outline).



1 = with grid fitting of stroke width to one pixel and thinning of curves by automatic inlining.
2 = with grid fitting of stroke width to two pixels and thickening of curves by automatic outlining.

URW produces the VS format (vector scaling), see also appendix L. This format is generated by giving specific parameters for a typeface and using the VS program. It takes about 8 up to 16 hours to prepare a VS format which can be used in a RIP (raster image processor) to perform “sizing with stem control”. This yields round about a performance as described in this chapter, leaving some arbitrary rastering which can only be avoided by manual raster corrections.

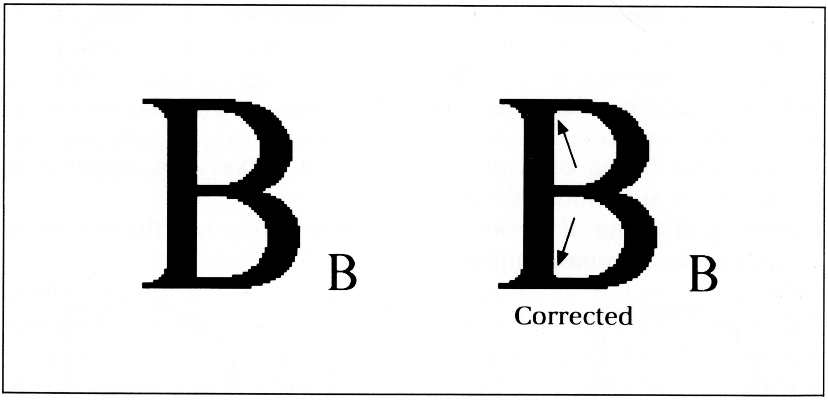
7.2 Manual corrections

In the following examples we mainly wish to bring the problems of automatic corrections to the attention of the reader and to stress the objective of achieving as perfect a type reproduction as possible.

Corrections on stems

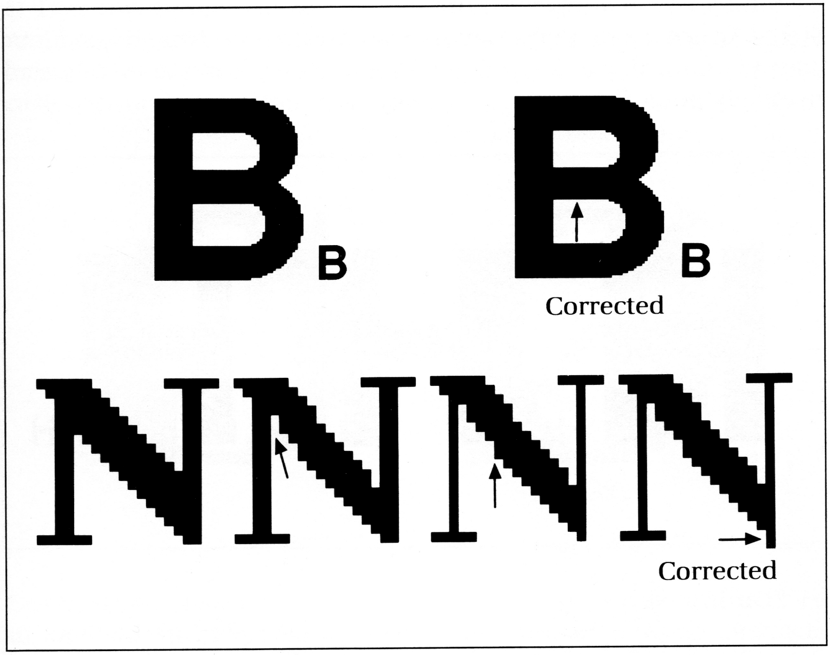
a) Straight stems

Letters which originally had slightly curved stems can become straightened out if the raster is too coarse. These straight stems sometimes cannot be automatically adjusted and have to be corrected by hand.



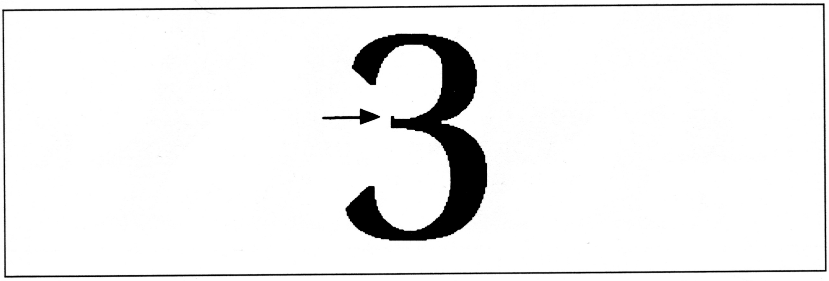
b) Stroke thicknesses

Rasters which are too coarse can lead to the loss of fine differences in stroke thicknesses. The lighter or heavier a typeface – compared with the standard version – and the coarser the display, the more difficult it is to decide for or against a scanline. This applies to horizontal, vertical, diagonal and curved strokes.


B
B
Corrected
Corrected

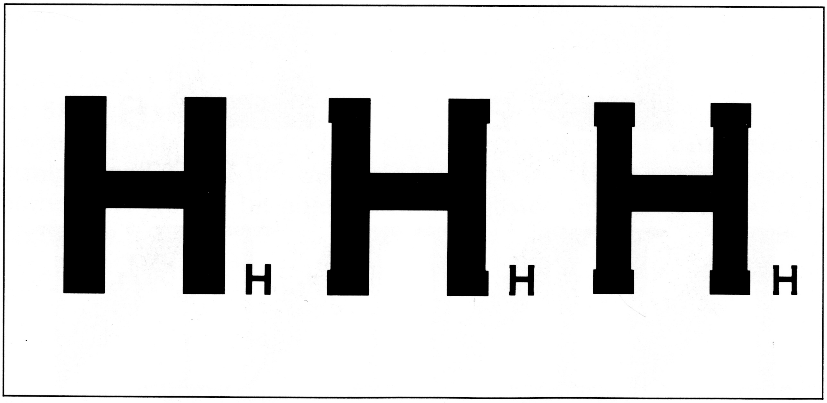
c) Flat curves become straight

When the raster is very coarse, very flat curves can be turned into straights. In the example below only one point is left of the original curvature and has to be deleted interactively.



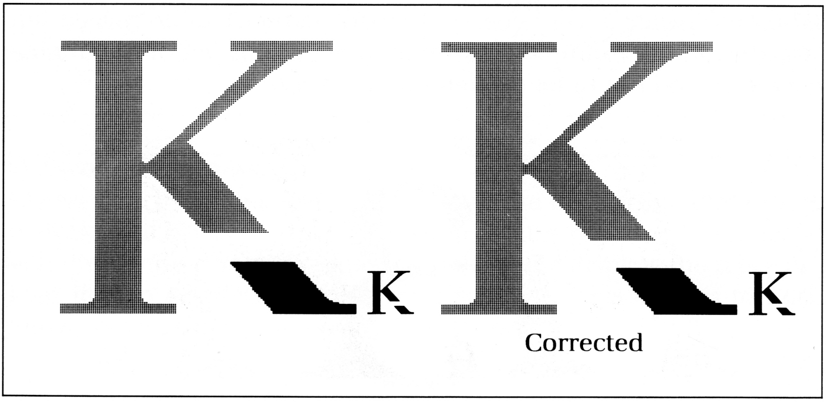
d) Stems with changes in ductus

Stems which have slight curves can be neither straightened nor adjusted. In order to keep them uniform, they have to be adjusted manually point for point.



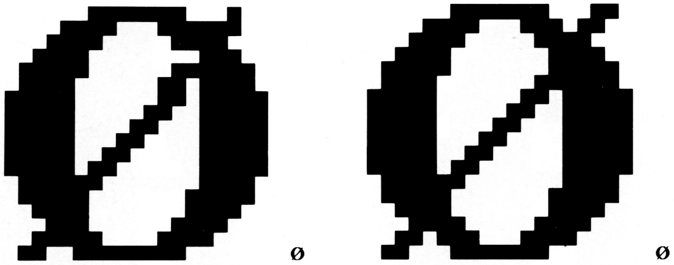
e) Scanline skips

Scanline skips appearing in curves, which are detrimental or detracting in their visual effect, have to be corrected manually.



f) Discontinuous curves

At the points where curved strokes and other segments of letters intersect, there is no possibility of automatic adjustment. In such case a manual operation is necessary.

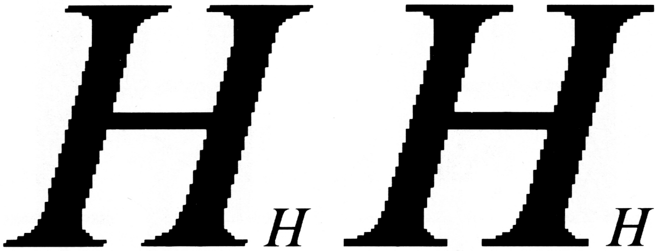


Corrected

Corrections of serifs

a) Serifs of italic types

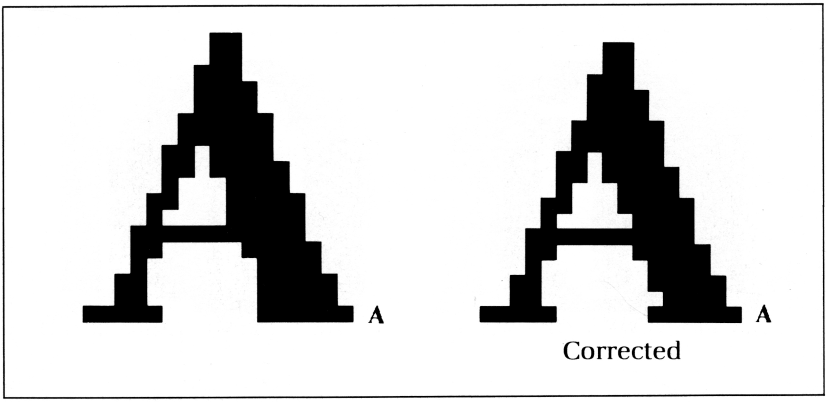
When the raster is coarse, the ends of serifs can be very problematic. In the example shown, the serif ends have an inclination of 0°. If one were to delete only one point, one would create a 45° slope.



Corrected

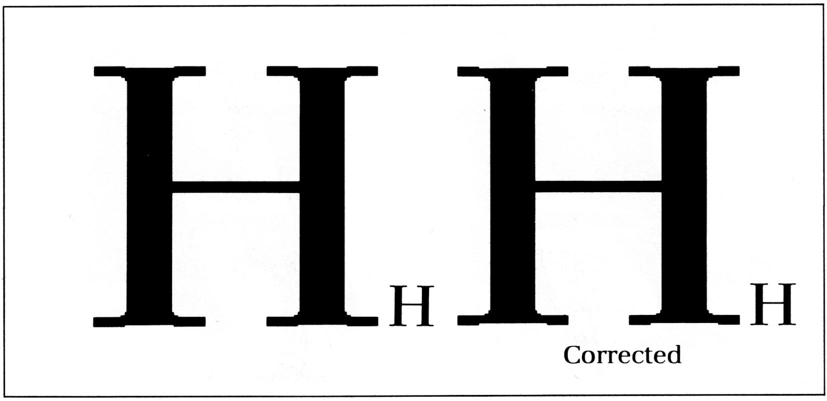
b) Serifs on diagonal stems

Serifs on diagonal stems cannot be adjusted automatically. In order to achieve a good transition from the stem into the serif, corrections are necessary when the raster is coarse.



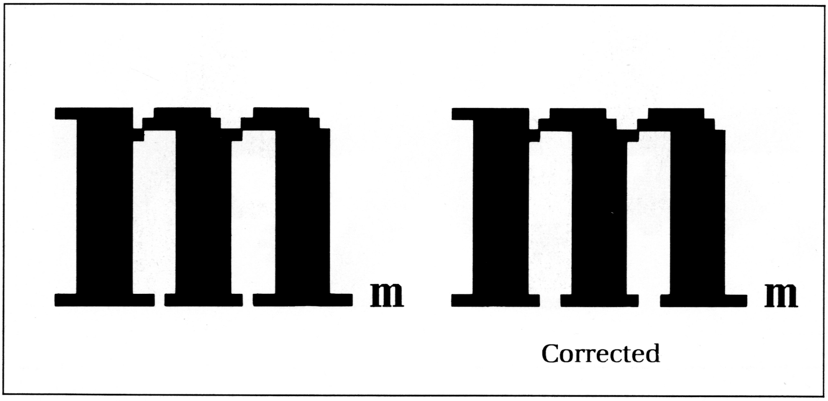
c) Flutes on serifs

Flutes on serifs cannot be treated automatically either. With a coarse raster one must decide how many scanlines need to be left out. Uniform flutes often have to be generated by hand.



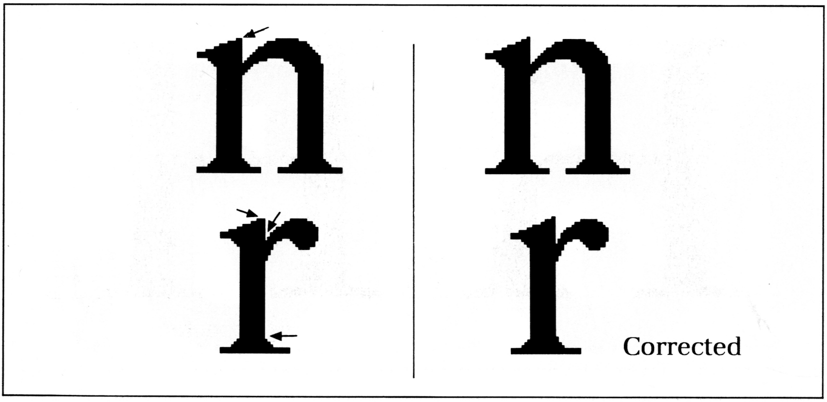
d) Serif lengths

With a coarse raster, serifs on letters m, n, w, v, y etc. can easily "intergrow". Whereas in some cases it is possible to deal with straight stems (m) automatically, diagonals always have to be corrected by hand.



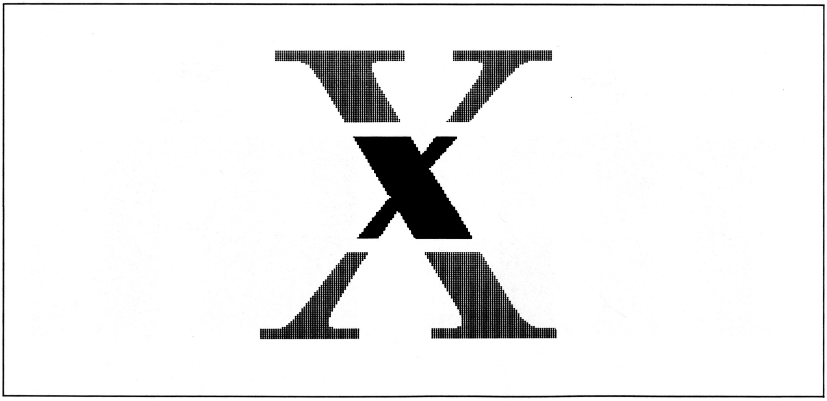
Corrections on segments of letters

Certain segments of letters (apart from horizontal serifs) can only be made to keep their uniform appearance through the use of interactive corrections.



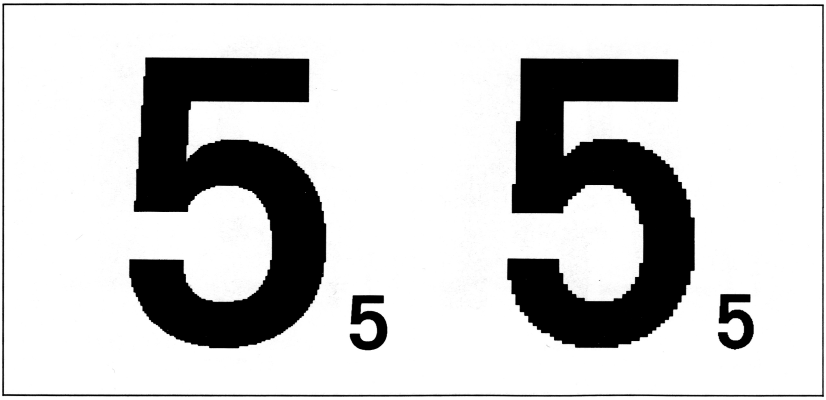
Intersection of diagonals

Rastering of intersections of diagonals often causes the form to appear random in shape. Such points have to be checked and possibly corrected manually.

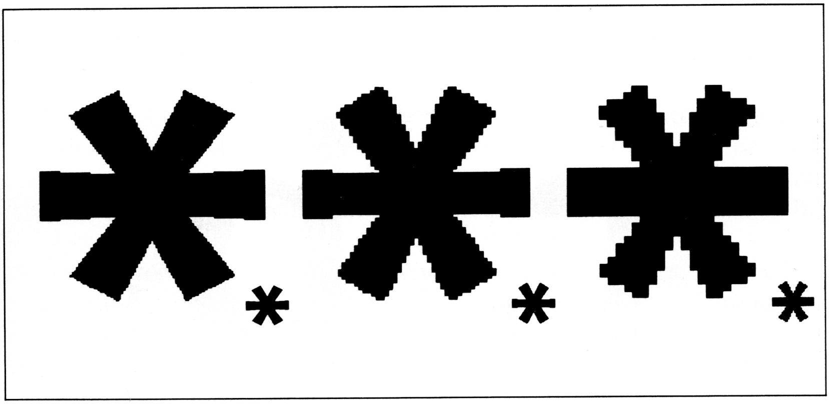


Stems with slight slopes

Slightly sloping stems produce problems when the raster is too coarse. The coarser the raster the fewer are the number of steps available to describe the inclination. The numeral 5 in a coarse raster causes the right slope of the vertical stem to disappear.



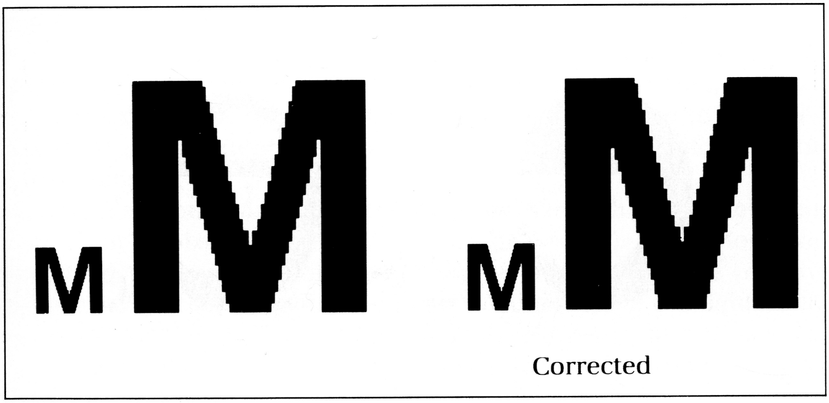
In the case of a special character such as the asterisk, the horizontal stroke can become simply rectangular as a result of coarse rastering.



Ink traps

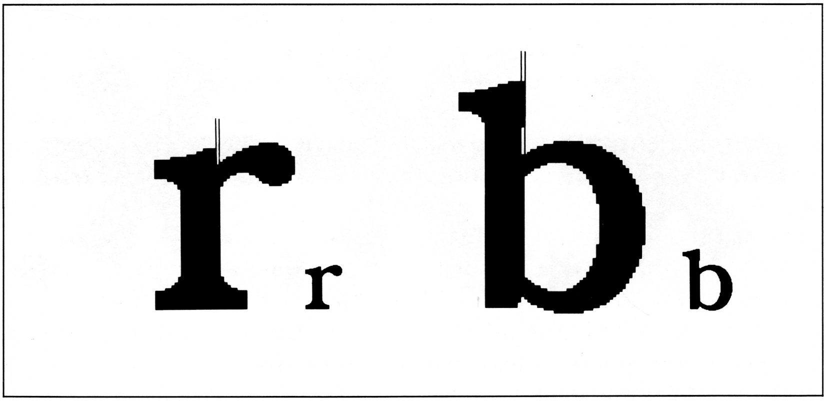
a) The optimum ink trap

Joints of letters having acute angles are often cut relatively deep for printing or repro reasons. This is achieved on raster letters by removing points. A result as in “M” is only possible using manual correction.



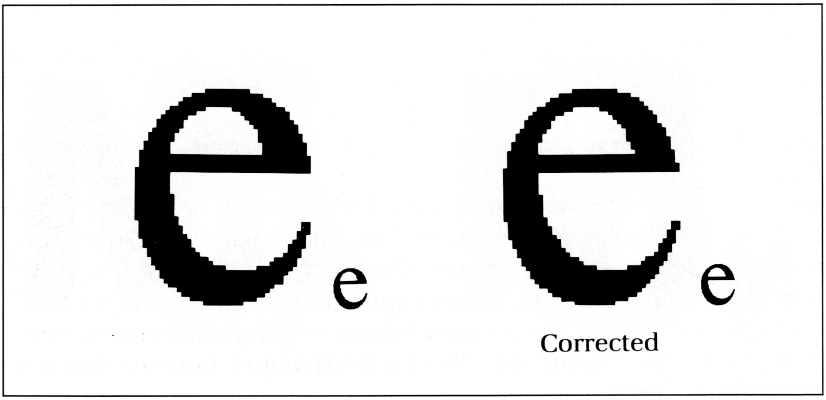
b) Changing ink traps

Coarse rastering can sometimes create exaggerations or distortions in the joints. The slope in the original then disappears, e.g. in the letters "r" and "b".



Tails

Rastering can sometimes cause the fineness of detail in the tails to disappear completely. When this is the case nothing but professional manual correction can hope to bring this fineness (of detail) back in a character.



7.3 SC formats for laser printers

It is already clear today that laser printers, LED printers and electro-erosion printers will continue to spread in the graphics industry in the future. They have long ago left their role as “fast printers for computers” in commercial usage. We are certain that the use of these devices as in-house printers and proof printers is going to expand. It is also apparent that they will be increasingly used in connection with PCs as “typewriters” in offices. It is only a question of price. The word from the industry is that by the year 1990 such printers will be available for $1000.

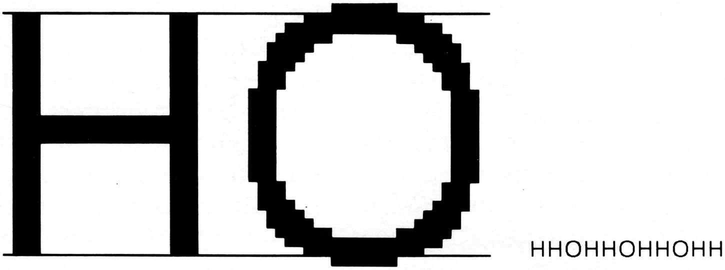
These printers are classified as low resolution printers, they write with 12 lines/mm, sometimes with 16 lines/mm or with 24 lines/mm (300 lines/inch, 400 lines/inch and 600 lines/inch).

The people developing type are aware that typefaces for this area of use need to be specially designed (ref. Bigelow).

Parallel to the development of new typefaces, the typefaces already in existence will have to be adapted for these printers. Provided one sticks to the use of proof printing for high resolution typesetting machines, one can accept certain quality losses. In this area it is mainly necessary to have a similar reproduction in order to gain an idea of the typography e.g., of a whole newspaper page. In general, the set width, point size and weight (boldness) have to be approximately the same. Laser printers are quite capable of meeting this objective from 12 lines/mm upwards.

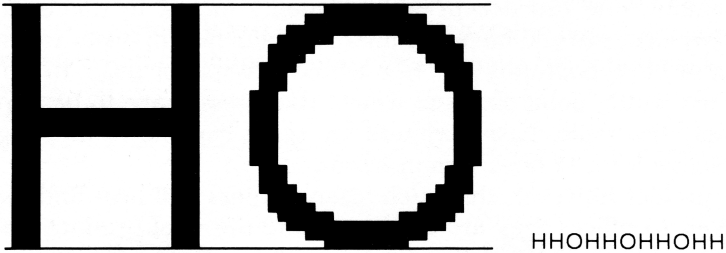
We predict however, that such laser printers will also find uses in offices. In offices they are used to create the final product, i.e. text and typography for reading. To this end typefaces have to be redesigned to some extent. The following must be taken into account when doing so:

The most common size for text is 9p. Body size is then 39 pixels and cap height 26 pixels at 12 lines/mm (300 lines/inch). In chapter 2 we described the overhang of round shapes. This overhang is usually around 1.5% of cap height. When capital letters have a height of 26 pixels (39 for the em), then round forms are given either 26 as well, or 28 pixels. This means that the cap overhang or base overhang is either 0% or 3.8%.



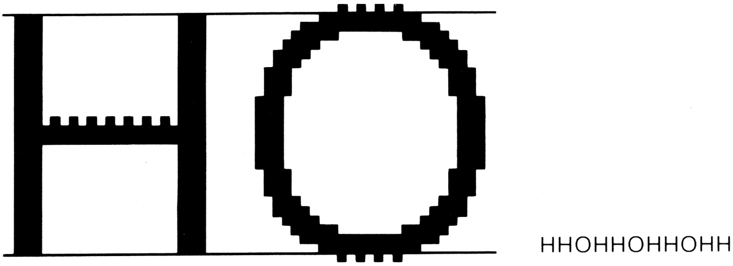
Raster images (39 × 39) with overhang.

Such a large overhang shows up and makes the "O" appear greater than an "H". On the other hand an "O" appears too small if it has no overhang.



Raster images (39 × 39) without overhang.

Half dots are, naturally enough, not available, but half lines can be created with very little effort, if next to a fully filled line one produces a new line consisting of alternating black and white pixels (half-bitting).



Raster images (39 × 39) with half-bitting.

As one can see on the “H”, it has a crossbar of 2.5 point thickness, as does the “O”. The overhang of the “O” is now approx. 1.5%, as it should be. It is interesting to note that with most laser printers one does not see a very distinct zigzagging along lines where the half bitting method has been used to produce stroke thicknesses with half point sizes. The manufacturers of such machines are lucky in that the physical effects (equalization of charge distribution, transfer of toner) produce a blending of the optical density.

On the other hand however, the above examples do show that only machines with writing densities of more than 24 lines/mm (600 lines/inch) are capable of producing the correct and important overhang. We would thus recommend all manufacturers of such machines to heed our experience, and try to aim for a writing density of 24 lines/mm (600 lines/inch) for their machines.

Even if individual points cannot be copied with the machine at a resolution corresponding to 24 lines/mm, the overall appearance of the individual letters will be finer and more pleasing to the eye. The type representations would have a higher quality.

8. Conclusions

We have been dealing with digital formats for 13 years. Eight years went by after the invention of the CRT machine by Dr. Hell before we started. We consider ourselves lucky that we had to begin with the control of drawing machines in order to cut original letters for photosetting, i.e. that right from the start we had to concentrate on the quality of digital type reproduction because of the size and accuracy of output required. In most typesetting machines the maximum letter height is approximately 3.1 cm, in drawing machines 10 cm is a standard height, and large starts at 100 cm.

This led us to discover the best data base. We held our peace for a long time before proclaiming that the IKARUS format is the only correct one for this purpose; at first we could not really believe that the most sensible procedure was the one of storing hand-digitized data. For a long time this appeared to us to be just too simple: after all, the basic concept did not require a great deal of thought.

It is probable that anyone who has to deal with graphics eventually ends up differentiating between three types of points (corners, tangents and curves). This is also a very natural process when analysing letter outlines. Starting points as a fourth type of point are only of importance to us in enabling the differentiation of individual closed outlines (for example the letter "O" has two outlines).

The coding of IKARUS points is thus extremely simple. The X and Y coordinates are coded with one word each and the point type is put into the sign bits of these two words, i.e. 4 bytes per point (see appendix I).

In discussing these matters with critical users, a further argument in the IKARUS format's favour made itself apparent: hand-digitizing almost automatically leads to a minimum of points being considered, because people tend to like saving work. It is thus almost natural that the IKARUS method is the method which requires the least number of contour points for the reproduction of an original letter, no matter how it was drawn. In this respect, it is of no consequence which method is used to produce smooth and rounded connections of the hand-digitized points. We are still of the opinion that in addi-

tion to our method (IK interpolation), the spline interpolations and Bézier method are also of use. We described the IK interpolation method in chapter 6.3 and have also explained why we stuck to our method.
These considerations led to a more detailed investigation of the properties of other formats.

8.1 Properties of formats

The following summary lists format properties in the sequence in which, during their short history, technicians have become interested in them.

E0: Electronics (speed)
Cost of electronics for the generation of control signals.

E1: Storage capacity (high res)
Storage capacity for high resolutions.

E2: Storage capacity (low res)
Storage capacity for low resolutions.

E3: Sizing
Possibilities for creating different type sizes from one original.

E4: Transformations
Possibility of displacing, rotating, italicizing and deforming type faces.

To these already well known and accepted properties we have added a few of our own:

E5: Input
Keeping input as simple as possible.

E6: User friendliness
Simple data structure for easy corrections.

E7: Presentation
Accurate output on flat bed drawing machines to allow comparisons with the original, and the output of lettering on self-adhesive material.

E8: Soft-scanning
Accurate, closed mathematical curve description in order to be able to use calculation methods to arrive at other digital formats, e.g. bitmaps, vector formats and run length codes.

E9: Programmer friendliness
Cost-effective programming of modifications; easy programming for new machine formats.

In the following table we have evaluated the properties of the individual formats as follows: 15 = very good ... 8 = satisfactory ... 0 = unsatisfactory.
The groups of properties have been divided into subtotals for
- machine format (E0...E2)
- typesetting machine format (E0...E4)
- data base (E5...E9).

In the past particular attention has been paid to properties E0 and E1. So we shall also pay particular attention to these, in sections 8.1.1 and 8.1.2.

	Machine format			Type-setter format		Data base format					Sums				
	Electronics (speed)	Storage capacity (high res)	Storage capacity (low res)	Sizing	Transformations	Input	User friendliness	Output	Soft-scanning	Programmer friendliness					
	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	E0+E1	E0+E2	E0-E4	E5-E9	E0-E9
IKARUS format	1	13	13	15	15	10	15	15	15	12	14	14	57	67	124
DI format	5	8	8	15	12	15[3]	12	15	8	10	13	13	48	60	108
VE format	7	15[1]	12	12	15	15[3]	10	12	7	8	22	19	61	52	113
SC format	9	15[1]	4	3	5	15[3]	7	8	6	2	24	13	36	38	74
BI format	9	15[1]	0	3	5	15[3]	6	6	5	2	24	9	32	34	66
GS format	9	13	0	3	5	15[3]	3	4	2	2	22	9	30	26	56
Adobe format	5	13	13	15	10	7	9	13	8	10	18	18	56	47	103
Bitstream format	5	8	8	12[2]	12[2]	10	15	15	15	12	13	13	45	67	112
Coueignoux format	9	15	15	10[2]	10[2]	10	10	6	8	8	24	24	59	42	101
Metafont format	0	3	3	12[2]	10[2]	3	12	10	8	15	3	3	28	48	76
Purdy format	10	13	13	12[2]	10[2]	4	10	8	8	8	23	23	58	38	96
XEROX spline format	5	10	10	12[2]	10[2]	12	9	9	8	8	15	15	47	46	93
Open vector format	13	15[1]	8	3	5	12	8	10	6	2	28	21	44	38	82
Closed vector format	7	15[1]	8	7	10	12	10	12	7	8	22	15	47	49	96
Run length format	14	15[1]	4	3	5	12	7	8	6	2	29	18	41	35	76
Bitmap format	15	15[1]	0	3	5	12	6	6	5	2	30	15	38	31	67

[1] Look also table and histograms for storage needs for different rasters

[2] These formats have a primary resolution of less than 4000 x 4000 pixel per em

[3] These formats could be calculated by computer

Comparison of formats.

8.1.1 Electronic requirements for the generation of control signals

It is clear that the electronic effort required increases correspondingly, as the digital reproduction of the formats used becomes more complex or compressed. We shall now attempt to make assessments for the manufacturing costs of the appropriate electronics – not for the development costs – and summarize these in the table below. The table contains details in the form of “number of IC boards” required for the generation of control signals from the particular digital form of data storage.

	Electronic 1	Electronic 2	Electronic 3	Electronic 4
IKARUS format	–	–	–	15
DI format	–	–	8	10
Open vector format	3	3	–	–
Closed vector format	4	4	7	10
Running length format	2	2	–	–
Bitmap format	1	1	–	–
Adobe format	3	6	10	10
Bitstream format	–	–	–	10
Coueignoux format	6	6	6	6
Metafont format	–	–	–	–
Purdy format	3	5	5	5
XEROX spline format	–	–	10	10

Electronic 1 up to 4 perform all about 500 characters per second in 10 pt size

Electronic 1: low resolution (VDT's, laser printer)
Electronic 2: high resolution (laser recorder, CRT-machines)
Electronic 3: high resolution with performances E2 and E3
(high resolution and sizing)
Electronic 4: high resolution with performances E2, E3 and E4
(high resolution, sizing, transformation)

Cost of electronics on basis
of number of IC boards in double Europe format.

The number of IC boards for the more complex formats could be reduced if one were to use the following method to generate the control signals:

- One stores the type as basic data format, which is in itself complex.
- Prior to setting the text, the typeface commands are searched for (font change commands).
- A preparatory process is started on a standard IC board (e.g. a CPU with 512 KByte RAM memory), in which for the required type the complex format is converted relatively slowly into a simple machine format using a program (approximately 40 char./sec.).
- The simple machine format is then stored in a buffer prior to the actual typesetting.

8.1.2 Storage requirements

In the framework of the IKARUS concept it is relatively easy to simulate special encodings, and thus to find the storage requirements for corresponding formats. In the following we show a table and two graphic presentations. The table contains an estimate of the storage required for complex formats. The diagrams show curves of the storage required as a function of the raster per em for complex, but also for simple formats. The storage requirement for complex formats is virtually independent of the resolution.

	Bytes per digitized point or element	Points per character	Bytes per character	General information and data for a typeface	KBytes per 100 latin characters	KBytes per 5000 Kanji characters
IKARUS-format	4	50	200	2	22	4950
DI-format	8	75	600	2	62	13950
VC-format	3	75	225	2	24.5	5513
Adobe-format	10	20	200	2	22	4950
Bitstream-format	7	75	525	4	56.5	12713
Coueignoux-format			25	10	12.5	2813
Metafont-format			400	20	60	13500
Purdy-format	5	40	200	5	25	5625
XEROX-spline-format	20	20	400	2	42	9450

Storage requirement for different formats.

The numbers show net values. Optionally, one can add storage for

- width tables,
- kerning/kissing tables,
- keyboard layouts,
- special typeface parameters and indicators.

The storage needs of Kanji can be estimated on the basis of IKARUS digitizations. Kanji characters have an average of 225 digitizations instead of 50, and thus require 4.5 times more storage space.

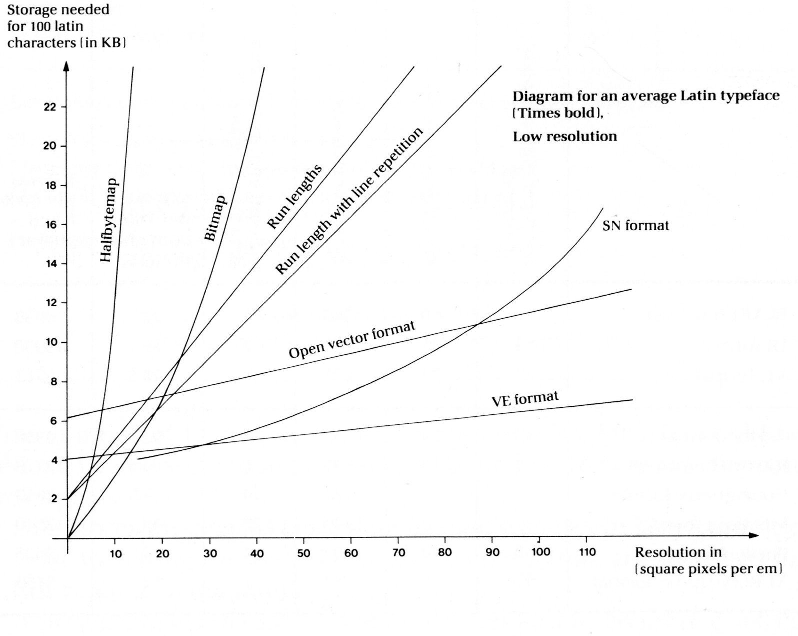


Diagram for an average Latin typeface (Times bold), low resolution.

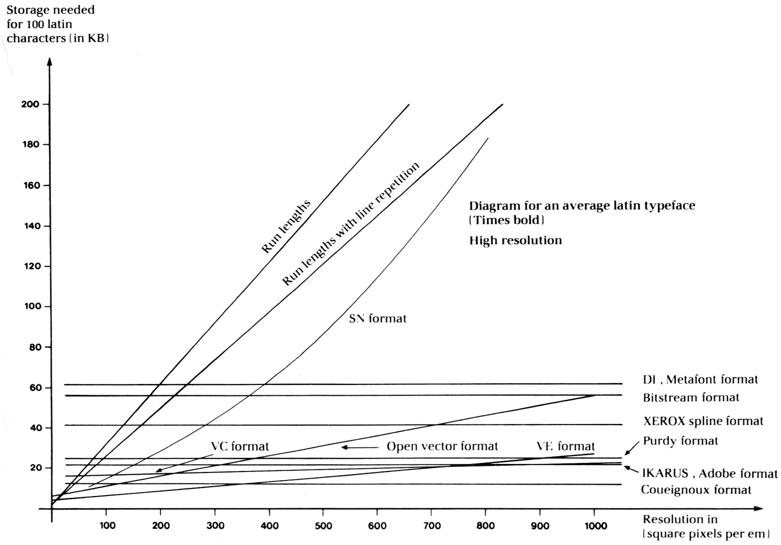


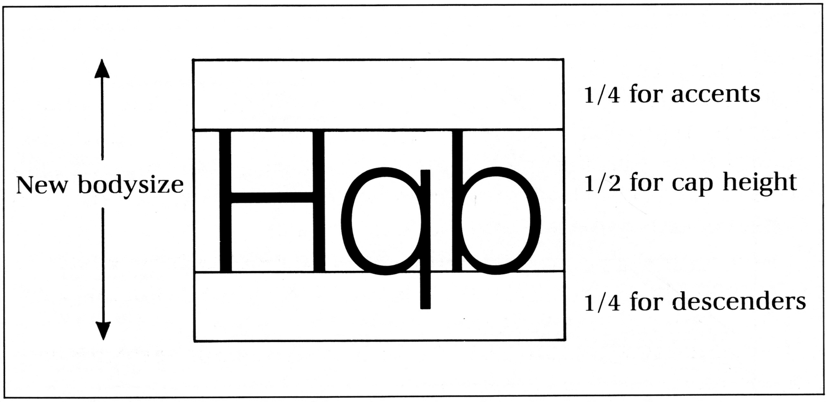
Diagram for an average Latin typeface (Times bold), high resolution.

8.2 Requirements to be met by formats

What follows is a summary of our findings as requirements to be met by formats.

- The raster resolution should be square.
- A data bank should be set up for future machines.
- Using this data bank, one should be able to calculate current and future machine formats (soft-scanning).
- The format of the data bank should be based on hand-digitization.

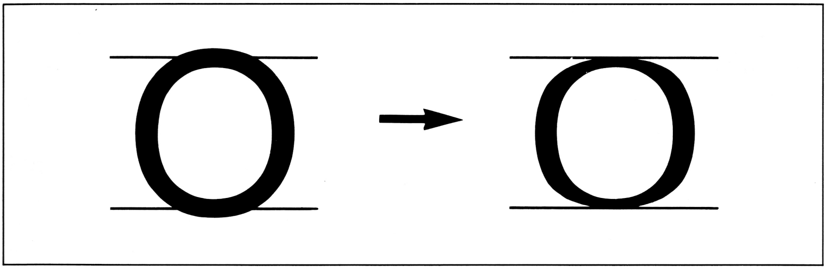
- The machine formats should be unified.
- It should be possible to exchange digital formats amongst different manufacturers.
- The right format for the data bank will allow manufacturers to change or expand the data more easily.
- The following em square division would appear in our opinion the most sensible:



This produces the following:
new body size = old body size × 1.33 = 2.0 × cap height.
Several firms have already introduced this and results have been satisfactory so far. The new body size is for storage purposes and does not determine the line spacing (leading) when typesetting. It would be even better to replace the term em by exposing window, selecting this window with dimensions equal to or slightly greater than the new em.

8.3 Recommendations for manufacturers

- Should the raster pattern be smaller than 50 × 50 pixels, the representation of overhangs necessary to the correct display of round forms within an alphabet will have a detrimental effect, causing the curves to appear flatter than they should.



- Laser printers should write with 600 lines/inch.
- Technicians should always remember one thing: the development of a new typesetting machine requires approximately 5 to 10 persons for the duration of 2 years. If one already has a good data base, then during this time 2 persons can work concurrently on the preparation of types and machine formats.
  To our knowledge it has been the case to date that the type is only developed when the machine is finished, and then as fast as possible. This has got to change!
- The descenders should have the same length as the ascenders in order to achieve better proportions.
- We would argue for fixed accents in the type library (data base).
- We also argue for complete and comprehensive kerning and touching tables in the data base.
- One should make efforts to allow variable type and/or keyboard setups. Every data base should be flexible in this area.
- Type should be loadable from a host computer and not be a fixed part of the typesetting machine.

8.4 Time required for producing type

In our type studio we have digitized approximately 1400 type versions to date (end of 1986) and can speak from experience.
On average we require 100 man-hours to digitize a font of 186 Latin characters (normal URW layout of a typeface) by hand in the IK format. For 186 Latin characters the work involved is divided as follows:

– Administration	10 h
– Marking	8 h
– Digitizing	8 h
– Correction/operating	24 h
– Spacing	20 h
– Design of missing characters	30 h
	100 h

The last item is due to the fact that on average original documentation usually contains about 120 characters. The missing 66 characters are then drawn, partly by hand and partly calculated using programs, or with the aid of graphic editors on a visual display terminal.
For the hand-digitization of Kanji type characters in Hamburg and Tokyo, we have come to the following values by experience (this also applies to a 186 Kanji character font):

– Administration	10 h
– Marking	24 h
– Digitizing	24 h
– Correction/operating	35 h
– Spacing	–
– Design of missing characters	?? h
	93 h

With regard to marking and digitizing, Kanji characters have on average 4.5 times the number of points contained in the average Latin letter. Despite this, the data preparation and digitizing takes only three times longer, approximately 15 minutes per Kanji character.
With regard to corrections, it should be noted that Kanji characters are drawn in the middle of the em square and appear more individual than Latin letters. The vertical strokes of Latin type are usually uniform within all the caps or lower case letters of a particular typeface. This can only be achieved by a relatively large amount

of corrective work. The originals are drawn by hand and therefore naturally have the inaccuracies of hand work, e.g. with respect to stroke widths. Fortunately, the same rigidity of rule does not apply to the individual Kanji characters, i.e. the amount of editorial work for Kanji is fairly limited.

We would, however, indicate the very large extent of a Kanji font, i.e. around 10,000 characters for “mincho” [roman] and approximately 6000 characters for “gothic” [sans serif].

The Japanese have – just as the Europeans or Americans – developed a large number of different type fonts and versions. We estimate that for all existing Kanji type one would require approximately 30 times the digitization work needed for all the Latin type in the western world.

In addition to the amount of effort involved in the preparation of IK formats, we also have an appreciable amount of manual work with the preparation of SC formats. The demands made by different firms and therefore the corresponding amount of work are very different. The effort involved with soft-scanning is fixed:

First point size parameterization	10 hours
Other point size parameterizations	4 hours

The next working steps take place on the graphic display. At this point we should perhaps say that some manufacturers of type offer digitizations which are of a quality lower than that of the results produced by automatic soft-scanning.

In our opinion corrections are always to be expected. There are just too many possibilities for graphic variations at joints, serifs and stroke intersections. No programmed procedure can be expected to deal with all these eventualities. On the other hand there are already high resolution machines available [60 lines/mm up to 100 lines/mm] which no longer require the correction of rasters made with soft-scanning.

The average amount of time required by us for the correction of 186 Latin type characters for each point size in a range of 50 × 50 up to

400 × 400 is about 15 hours, while the first point size of all point sizes of a particular version usually takes between 30 to 45 hours.
The production of digital type is therefore expensive. It is for this very reason that when preparing a data base, the digitization of the typeface should only be required **once in the life of that typeface.** Once it is stored one only needs a relatively small amount of rastering work for each machine, whether available now or yet to be developed.

Appendices

Appendix A
Type classification

There are several competing classifications. We follow the DIN-classification based on proposals made by the ATYPI (Association Typographic Internationale).

The American and English standards use 9 groups of typefaces, we have added group 10 for the black letters and group 11 for eccentric typefaces. We like to use group 11 to gather all those typefaces, which are hard to read, and are therefore only of limited use, except maybe in advertizing.

A few years ago, an ISO group has been established to work on international font standards (ISO/TC97/SC18). Unfortunately, their work has not been finished to date, but it shows promising results (ref. ISO).

Group 1
Venetian Serif

Characteristic to this group are the sloped cross stem of the lower case e and the sloped (45 degree) up-stroke of the stems of lower case characters. The axis of bowls is slightly slanted to the left.

Centaur

Schneidler

Trump Mediaeval

Group 2
Old Face/Old Style
The cross stem of the lower case e is horizontal. The terminals of the upper case and the vertical stems of the lower case curve smoothly into the serifs.

Bembo
Palatino
SABON-ANTIQUA

Group 3
Transitional
The differences between thickness of hairlines and stems are greater. The axis of the bowls is nearly vertical.

Baskerville
Caslon
Concorde
Times

Group 4
Modern Face/Modern Roman

The serifs are smooth and horizontal. The stems do not curve smoothly into the serifs. The axis of bowls is vertical. Differences in thickness between hairlines and stems are more extreme here.

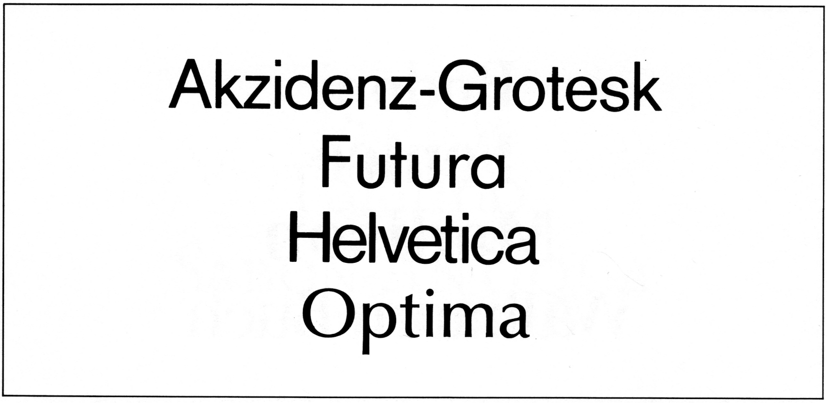
Bodoni
Fenice
Madison
Walbaum Buch

Group 5
Egyptian Slab/Serif Antique

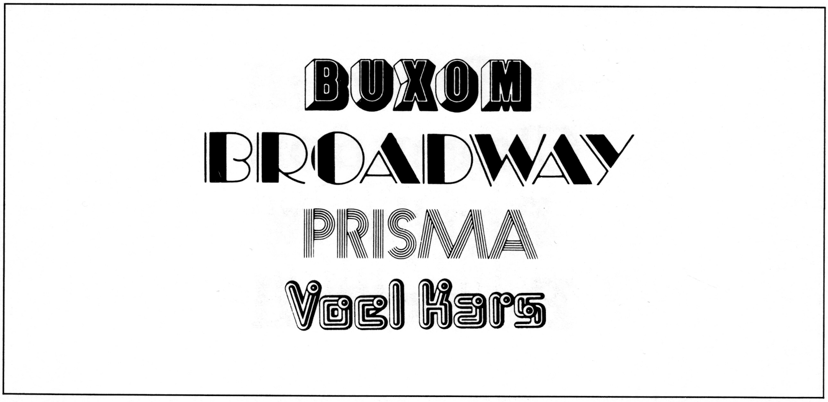
Characteristic to this group are the slab serifs. Hairlines and strokes are mostly as thick as the terminals.

Beton
Clarendon
Egyptienne
Rockwell

Group 6
Sans Serif/Gothic
This group of typefaces has no serifs, and is also recognized by the name "Grotesque". Crossbars and stems are optically of the same thickness.


Akzidenz-Grotesk
Futura
Helvetica
Optima

Group 7
Display Roman
These roman versions are not classifiable within the first six groups, due to their widely differing ductus.


BUXOM
BROADWAY
PRISMA
Voel Kars

Group 8
Scripts

These typefaces have been developed from writing at schools and chancelleries. The roman italics are however not to be mistaken for members of this group.

Brush Script
Commercial Script
Murray Hill
Palace Script

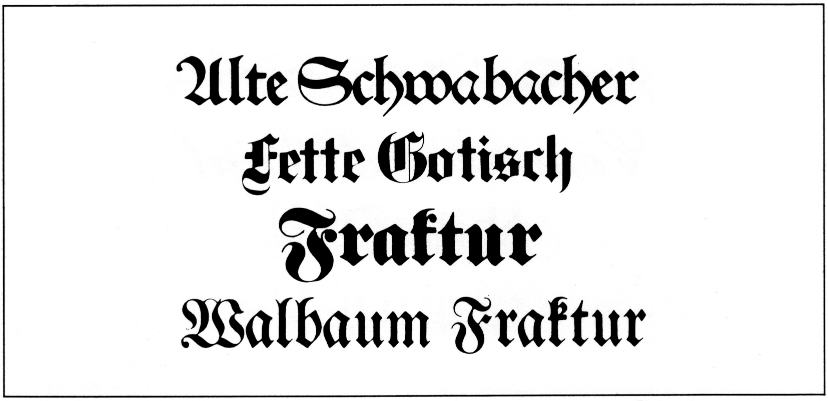
Group 9
Graphic

These typefaces have been developed from the hand-written forms of the roman typefaces.

Time-Script
Post-Antiqua
Pracht-Antiqua

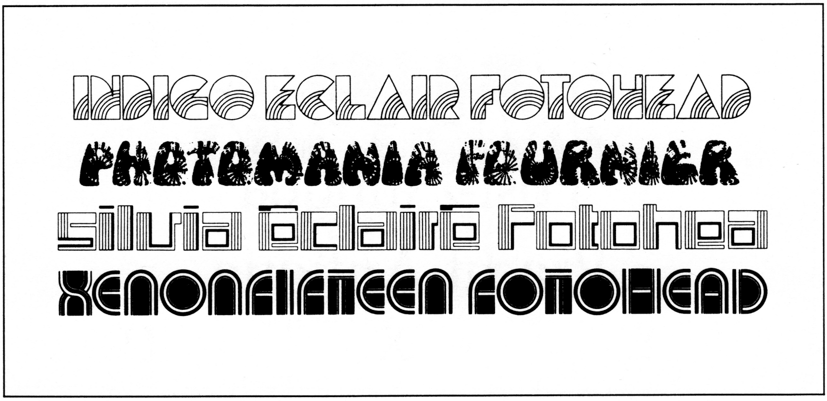
Group 10
Black Letter

These typefaces mostly have a condensed and irregular lower case. The upper case is decorated with hairlines and has forms full of verve. This group usually does not exist in English classifications.


Alte Schwabacher
Fette Gotisch
Fraktur
Walbaum Fraktur

Group 11
Eccentrics

This group does not exist, but the author wants to show typefaces that are almost illegible.


INDIGO ECLAIR FOTOHEAD
PHOTOMANIA FOURNIER
silvia eclaire fotohead
XENONFIFTEEN FOTOHEAD

Appendix B
Characters of a typeface

Upper case

101	A	113	M	125	Y
102	B	114	N	126	Z
103	C	115	O	127	Æ
104	D	116	P	128	Œ
105	E	117	Q	129	Ø
106	F	118	R	201	Ä
107	G	119	S	208	Å
108	H	120	T	210	Ç
109	I	121	U	215	Ð
110	J	122	V	261	Þ
111	K	123	W	237	Ö
112	L	124	X	251	Ü

Lower case

301	a	314	n	327	æ
302	b	315	o	328	œ
303	c	316	p	329	ø
304	d	317	q	330	ß
305	e	318	r	331	ı
306	f	319	s	332	ȷ
307	g	320	t	401	ä
308	h	321	u	408	å
309	i	322	v	413	ç
310	j	323	w	436	ö
311	k	324	x	449	ü
312	l	325	y	459	ð
313	m	326	z	460	þ

Numerals

501	1	546	4	581	7
502	2	547	5	582	8
503	3	548	6	583	9
504	4	549	7	584	0
505	5	550	8	665	¼
506	6	551	9	662	½
507	7	552	0	666	¾
508	8	575	1	663	⅓
509	9	576	2	664	⅔
510	0	577	3	511	£
543	1	578	4	512	$
544	2	579	5	513	¢
545	3	580	6	516	¥

Punctuation marks, special characters

601	.	614	!	627	)
602	:	615	¡	628	[
603	·	616	?	629	]
604	·	617	¿	630	&
605	.	618	»	631	§
606	...	619	«	632	†
607	,	620	›	633	‡
608	;	621	‹	634	*
609	’	622	/	646	⅍
610	‘	623	-	698	%
611	”	624	–	699	‰
612	“	625	—	637	@
613	„	626	(	638	#

Special characters and floating accents

648	©	701	¨	751	¨
649	®	702	˙	752	˙
650	TM	703	˚	753	˚
651	¶	704	´	754	´
652	¤	705	`	755	`
639	°	706	^	756	^
635	′	707	ˇ	757	ˇ
636	″	708	˘	758	˘
640	+	709	~	759	~
641	−	710	˝	760	˝
642	×	711	¸	761	¸
643	÷	713	˛	763	˛
644	=	714	¯	764	¯

Special character designations

We assume that we rarely need to give the names for upper and lower case, or for numerals, whereas we give the names of punctuations and other special characters and accents completely. The character numbers are listed sequentially.

127 – Upper case AE dipthong
128 – Upper case OE dipthong
129 – Upper case O with sloped stem
201 – Upper case A with umlaut
208 – Upper case A with angstroem
210 – Upper case C with cedilla
215 – Upper case D with horizontal stroke
237 – Upper case O with umlaut
251 – Upper case U with umlaut
261 – Upper case Thorn (Icelandic)
327 – Lower case ae dipthong
328 – Lower case oe dipthong
329 – Lower case o with sloped stem
330 – German eszett (double s)
331 – Lower case i without dot
332 – Lower case j without dot
401 – Lower case a with umlaut
408 – Lower case a with angstroem
413 – Lower case c with cedilla
436 – Lower case o with umlaut
449 – Lower case u with umlaut
459 – Sound notation for th
460 – Lower case thorn (Icelandic)
501-510 – Tabular figures
512 – Pound Sterling
543-552 – Mediaevals (old style figures)
601 – Period
602 – Colon
603 – Bullet

604 – Dot (Catalonian)
605 – Leader dot
606 – Ellipsis
607 – Comma
608 – Semicolon
609 – Apostrophe
610 – Single upper quotation mark
611 – Double upper quotation mark (end 99)
612 – Double upper quotation mark (start 66)
613 – Double lower quotation mark
614 – Exclamation mark
615 – Inverted exclamation mark (Spanish)
616 – Question mark
617 – Inverted question mark (Spanish)
618 – French citation mark (start), guillemet
619 – French citation mark (end), guillemet
620 – Single French citation mark (start), guillemet
621 – Single French citation mark (end), guillemet
622 – Slash
623 – Hyphen
624 – En-dash
625 – Em-dash
626 – Open parenthesis
627 – Close parenthesis
628 – Open bracket
629 – Close bracket
630 – Ampersand
631 – Section mark
632 – Single dagger
633 – Double dagger
634 – Asterisk
635 – Single vertical quote
636 – Double vertical quote
637 – Commercial at
638 – Number sign
639 – Degree sign
640 – Plus
641 – Minus

642 – Multiplication
643 – Division
644 – Equal
646 – A/S from 60% upper case
648 – Copyright
649 – Registered
650 – Trademark
651 – Paragraph mark
652 – General currency symbol
661-676 – 60% fractions
698 – Percent
699 – Per mille
701 – Upper case accent umlaut
702 – Single dot of upper case accent umlaut
703 – Upper case accent angstroem
704 – Upper case accent acute
705 – Upper case accent grave
706 – Upper case accent circumflex
707 – Upper case accent caron
708 – Upper case accent breve
709 – Upper case accent tilde
710 – Upper case accent double acute (Hungarian)
711 – Upper case accent cedilla
713 – Upper case accent hook (Polish/Lithuanian)
714 – Upper case accent macron
751 – Lower case accent umlaut
752 – Single dot of lower case accent umlaut
753 – Lower case accent angstroem
754 – Lower case accent acute
755 – Lower case accent grave
756 – Lower case accent circumflex
757 – Lower case accent caron
758 – Lower case accent breve
759 – Lower case accent tilde
760 – Lower case accent double acute (Hungarian)
761 – Lower case accent cedilla
763 – Lower case accent hook (Polish/Lithuanian)
764 – Lower case accent macron

Appendix C
Accents for latin type

Albanian	Albanian 3,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÇçËë «H» “H„
Finnish-Ugrish	Estonian 1	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÄäÕõÖöÜü (ČčŠšŽž) «H» „H“
	Finnish 4,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÄäÖö "H" »H» 'H'
	Lappish 0,038	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
	Hungarian 13	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÉéÍíÓóÖöŐőÚúÜüŰű „H” »H«
Celtic	Breton 1	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÉéÈèÊêÏïÑñÜü
	Gaelic 0,08	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀàÉéÌìÓóÒòÙù
	Irish 0,4	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÉéÍíÓóÚú “H” ‘H’ H–H
	Welsh h 0,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÂâÄäÉéÊêËëÎîÏïÔôÖöÙùÛûÜüŴŵẄẅŶŷŸÿ
Germanic	Africaans 4	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz „H” ‘H’ H–H ÁáÀàÄäÉéÈèÊêËëÍíÌìÎîÏïÓóÒòÔôÖöÚúÙùÛûÜü
	Danish 5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÅåÉéØøÆæ »H« „H“
	German 100–120	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÄäÖöÜüß „H“ »H« H – H

Taken from Berthold Fototypes EDITION 2.

	English 350–370	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz “H” ‘H’ H–H
	Faroen 0,036	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÐðÍíÓóØøÚúÝýÆæ
	Frisian 0,3	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÂâÉéëïÊêÔôöÚúÛû
	Dutch 19	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz „H” ”H” ÁáÀàÂâÄäÉéÈèÊêËëÎîÏïÓóÒòÔôÖöÛûÜü
	Icelandic 0,2	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÐðÉéÍíÓóÖö ÞþÚúÝýÆæ „H“ ‘H’
	Norwegian 4	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀàÅåÉéÈèÒòØøÔôÆæ «H»
	Swedish 8,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÅåÄäÉéÖö ”H” »H» ’H’
Romanic	**French** 80–90	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀàÂâÇçÉéÈèÊêËëÎîÏïÔôÙùÛûÜüÆæŒœ «H»
	Italian n 60–65	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀàÈèÉéÌìÎîÒòÓóÙù «H» “H„
	Catalonian 5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀàÇçÉéÈèÍíÏïÓóÒòÚúÜü
	Latin †	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz „H“
	Portugese 125–135	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz «H» “H” ‘H’ ÁáÀàÂâÃãÇçÉéÈèÊêÎîÏïÓóÒòÔôÕõÚúÙù

Taken from Berthold Fototypes EDITION 2.

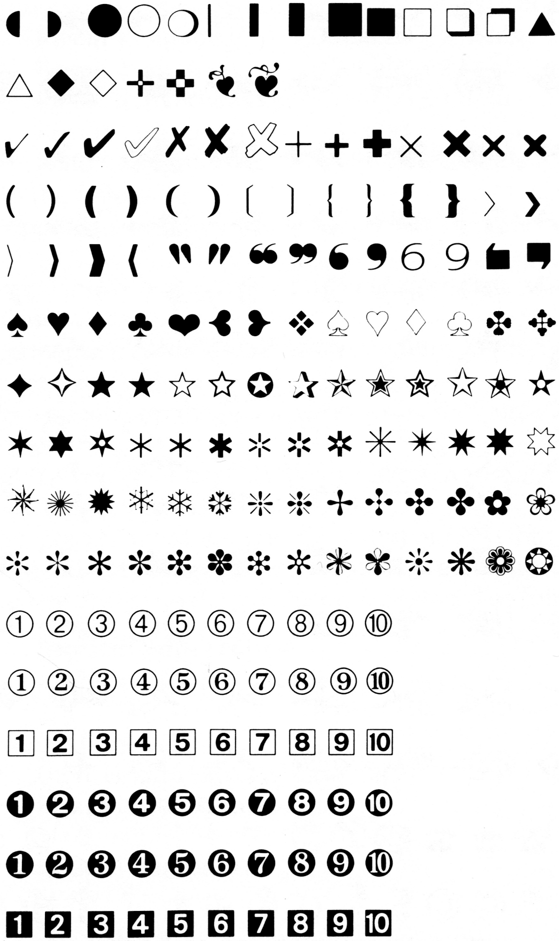
Romanic	Ratoromanian 0,6	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÂâÉéÈèÊêÎîÏïÒòÔôÖöÙùÜü
	Rumanian 22	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĂăÂâÎîŞşŢţ „H“ «H» ‚H‘
	Spanish 220–225	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÉéÍíÑñÓóÚúÜü ¿H? ¡H! «H» “H” ‘H’ H–H
Baltic	Lithuanian 2,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĄąČčĖėĘęĮįŠšŲųŪūŽž „H“ «H»
	Lettish 1,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĀāČčĒēĢģĪīĶķĻļŅņŖŗŠšŪūŽž «H» „H“
Slawian	Croatic 5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĆćČčĐđŠšŽž »H«
	Lower sorbic 0,025	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ČčĚěŁłŃńŔŕŚśŠšŹźŽž „H“
	Upper sorbic 0,025	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĆćČčĚěŁłŃńÓóŘřŠšŹźŽž „H“
	Polish 34	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĄąĆćĘęŁłŃńÓóŚśŻżŹź „H“ »H« ‚H‘
	Slovak 4,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÄäČčĎďÉéÍíĹĺĽľŇňÓóÔôŔŕŠšŤťÚúÝýŽž „H“ »H«
	Slowenian 2	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ČčŠšŽž »H« ‚H‘
	Czech 9,5	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáČčĎďÉéĚěÍíŇňÓóŘřŠšŤťÚúŮůÝýŽž „H“ »H«

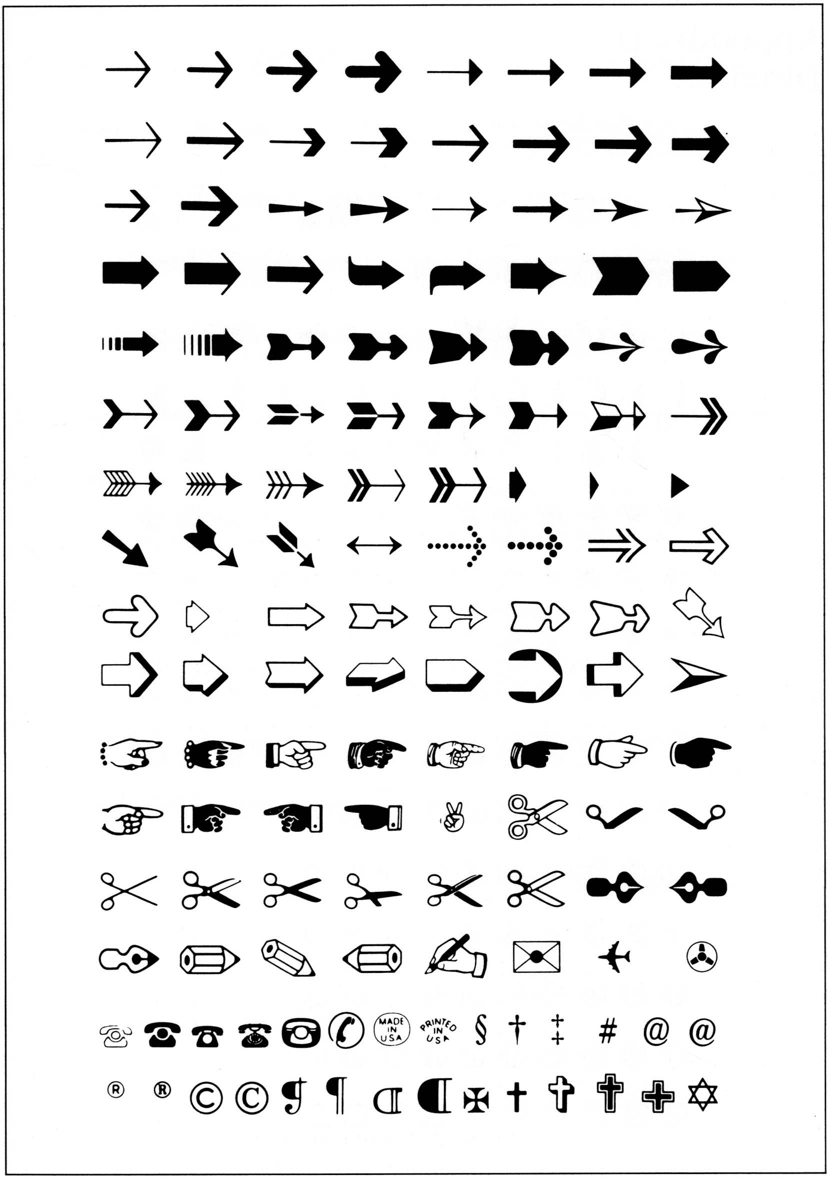
Taken from Berthold Fototypes EDITION 2.

Others	Basque 0,7	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÇçD̄d̄L̄l̄N̄n̄ÑñŔŕR̄r̄T̄t̄Üü
	Esperanto (3–5)	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ĈĉĜĝĤĥĴĵŜŝŬŭ
	Haussa 15	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
	Indonesian 80	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz Éé 'H' ‘H’
	Malagassi 4	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ‘H’
	Maltese 0,3	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÀĊċĠġĦħŻż
	Samoan 0,2	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz Ōō
	Suaheli 15	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz
	Tagalog 8	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÁáÀàÂâÉéÈèÊêG̃g̃ÍíÌìÎîÑñÓóÒòÔôÚúÙùÛû
	Turkish 34	ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz ÂâÇçĞğİıÎîÖöŞşÛûÜü «H» “H„ ‘H’
	Vietnamese 50	ÁÀẢÃẠĂẮẰẲẴẶQ̂Q̂́Q̂̀Q̂̉Q̂̃ẬĐÉÈẺẼẸÊẾỀỂỄỆÍÌ ỈĨỊÓÒỎÕỌÔỐỒỔỖỘỚỜỞỠỢÚÙỦŨỤỨỪỬỮỰỵ
		áàảãạăắằẳẵặq̂q̂́q̂̀q̂̉q̂̃ậđéèẻẽẹêếềểễệíìỉĩị óòỏõọôốồổỗộơớờởỡợúùủũụưứừửữựỵ

Taken from Berthold Fototypes EDITION 2.

Appendix D
Dingbats




MADE IN USA
PRINTED IN USA

Appendix E
Explanation of optical effects

We confronted approximately 130 people with questions 1 to 5 at URW in Hamburg, and obtained the following statistical answers:

Result 1 (squares): Field b9 ± 2 fields
Result 2 (circles): Field b9 ± 2 fields
Result 3 (overhangs): Field b3 ± 1 field
Result 4 (diagonals): Field a4 ± 2 fields
Result 5 (apices): Field b2 ± 2 fields

We conclude the following:

- A square appears optically correct when it is 1% ± 1% taller than it is wide.
- A circle appears to be optically correct when it is 1% ± 1% taller than it is wide.
- A circle appears optically as tall as a rectangle when it has an cap and base overhang of 1.5% ± 0.5% respectively.
- A triangle appears optically as wide as a rectangle when it is 5% ± 1% wider.
- A sharp apex (A,V,W) appears to be as high as a straight only when it is 3% ± 1% longer than the square side.

It is of course possible that the people tested at URW have a certain bias, which we did not recognize. We would therefore ask our readers to try out the test and send the results on a postcard as follows:

“optical appearance”
a7, b9, c4, b3, b2 (example)

to the following address:

URW Unternehmensberatung
c/o Dr. Peter Karow
Harksheider Straße 102
D–2000 Hamburg 65
West Germany

We guarantee that the data and results sent in by readers will be used only for the improvement of the statistical base.

Appendix F
Short dictionary of type terminology

English	French	German
accent	accent	Akzent
accented character	lettre accentuée	Akzentbuchstabe
adjustment	ajustement, adaptation	Anpassung
aesthetic box	programme esthétique	Ästhetik-Tabelle
angle of italicization	angle d'italisation, inclinaison	Kursivwinkel
to antique	antiquer	antiquieren
artwork	original	Schriftoriginal
ascender	longue du haut	Oberlänge
automatic channelling	canalisation automatique	Kanalautomatik
bar	bras	Schwengel
baseline	ligne d'écriture, ligne de base	Grundlinie, Schriftlinie
bearing value	approche	Fleisch
black	extra gras	schwarz, extrafett
blackletter	caractère gothique	Fraktur
blending	fusionée	verschmelzend
body	corps de lettre	Kegel
body size	hauteur du corps	Kegelhöhe
bold	gras	dick, fett
border	cadre, bordure	Rahmen
bounding box	rectangle d'encombrement	umschreibendes Rechteck
bow	arc	Bogen
bowl	rond	Rundung
broken	fracturée	gebrochen

English	French	German
calligraphy	calligraphie	Kalligraphie
cap height	hauteur des capitales	Versalhöhe
cathode ray	rayon cathodique	Kathodenstrahl
character	lettre caractère	Buchstabe
character style	forme de la lettre, style	Buchstabenform
composition	composition	Satz
to condense	condenser	kondensieren
condensed	étroite	schmal
contour	contour	Kontur
to contour	dessiner le contour	konturieren
corner point	point d'angle	Eckpunkt
counter	contre poinçon	Innenraum, Punze
cross stem	trait horizontal	Querstrich
curve	courbe	Kurve
curve adjustment	compensation des courbes	Kurvenausgleich
curve point	point de courbe	Kurvenpunkt
data base	base des données	Datenbasis
dancing	valsante	tanzend
decorative typeface	alphabet gracile	Zierschrift
demi (bold)	demi-gras	halbfett
descender	jambage inférieur	Unterlänge
diagonal	diagonale	Diagonale
digital	digital, numérisé	digital
digitalization	digitalisation	Digitalisierung
digital representation	représentation digitale	digitale Darstellung
display typeface	caractéres de titre, caractéres de titrage	Auszeichnungsschrift, Displayschrift
dot	pixel, point de trame	Rasterpunkt
down-stroke	plein	Abstrich
ductus	ductus	Duktus, Strichführung

English	French	German
ear	oreille	Ohr
em square	cadratin	Geviert
to enlarge	agrandir	vergrößern
to expand	élargir	expandieren
expanded	élargi, large	breit
exponent	exposant	Exponent
extension	sortie gracile, paraphe	Auszug
extra bold	extra gras	extra fett
extra light	extra maigre	extra leicht
fixed accent	accent fix	Festakzent
floating accent	accent flottant	fliegender Akzent
foot note	note en base (de page courant)	Fußnote
form setting	composition formée	Formsatz
formula setting	composition de formules	Formelsatz
foundry	fonderie	Gießerei
fraction	fraction	Bruchziffer
grid	grille	Gitter, Raster
grid size	grille	Raster
grotesque	style grotesque, (sans patin)	grotesk
hairline	délié	Haarlinie
headline	titre	Headline, Überschrift
high resolution	haute résolution	feine Auflösung
hot metal	composition au plomb	Bleisatz
index	index	Index
indentation	renfoncement	Einzug im Text
initial	lettre initiale	Initial

English	French	German
ink trap	renfoncement du caractère	Einzug im Buchstaben
interpolation	interpolation	Interpolation
italic	italique	kursiv
to italicize	pencher, italiser	kursivieren
job printing	travaux de ville	Akzidenzdruck
join	entrée	Einlauf
kerning	à crénage	unterschneidend
kerning table	tableau de crénage	Unterschneidungstabelle
laser beam	rayon laser	Laserstrahl
laser printer	copieuse laser	Laserdrucker
leading	interlignage	Durchschuß
left side bearing (value)	approche gauche	Vorbreite
letter space	espace des caractères	Buchstaben-Zwischenraum
letter spacing	interlettrage	Spationierung
ligature	ligature	Ligatur
light	maigre	dünn, leicht, mager
line	ligne	Linie, Zeile
line element	filet	Linienelement
line graphic	reproduction au trait	Strichgraphik
line resolution	résolution par ligne	Linienauflösung
line spacing	interlignage	Durchschuß
link	liaison	Steg, Verbindung
logo(type)	logo(type)	Logo(type)
loop	boucle	Schleife
lower case (characters)	bas de casse, minuscules	Gemeine, Minuskeln
low resolution	basse résolution	grobe Auflösung
mean line	hauteur des minuscules	Minuskelhöhe

English	French	German
medium	normal	normal
mirroring	effet miroir	spiegelnd
modification	modification	Modifikation
monospaced	chasse de fixe	dicktengleich
numeral	chiffre	Ziffer
original	original	Schriftoriginal
outline	contour	Kontur
overhang	avance	Überhang
overlapping	superposée	überdeckend
overlapping table	table pour superposer	Überdeckungstabelle
performance specification	cahier des charges	Pflichtenheft
photo type setting	photocomposition	Fotosatz
pixel	pixel, point de trame	Pixel, Rasterpunkt
point	point	Punkt
point size	corps	Punktgröße, Schriftgrad
punctuation	ponctuation	Interpunktion
punctuation mark	signe de ponctuation	Interpunktionszeichen
rectangular alignment	alignement automatique	Kanalverarbeitung
to reduce	réduire	verkleinern
resolution	résolution	Auflösung
resolution mark	pointe	Spitze
right side bearing (value)	approche de droite	Nachbreite
roman typeface	romain, elzévir	Antiqua (Schrift)
to rotate	faire une rotation	rotieren
to round	arrondir	runden, verrunden
run length code	codage des parcours	Lauflängenkodierung
running width	approche de chasse	Laufweite

English	French	German
sans serif	style grotesque (sans patin)	grotesk
scan data	données de scanning	Rasterdaten
scanner	scanner	Scanner
scanning	scanning (analyse)	Aufrasterung
serif	patin, empattement	Serife
serif type	style romain	Antiqua (Schrift)
setting	composition	Satz
sexy spacing	sexy spacing	sexy spacing
to shadow	ombrer	schattieren
shaping	déformée	verformend
shoulder	épaule	Schulter
to size	mettre à la cote	umgrößern
spacing (letter ~)	chasse de caractères (de l'alphabet)	Zurichtung
small caps	petites capitales	Kapitälchen
sparkling (bouncing)	valsante	tanzend
special setting	chasse spéciale	Spezialsatz
spline	spline	S-Kurve
spur	compensation extérieur, éperon	Sporn
starting point	point de début	Anfangspunkt, Startpunkt
stem	trait, jambage	Balken, Grundstrich
stem edge	bornée	Balkenrand
stem width	épaisseur de trait	Balkenstärke, Strichstärke
stress	épaissement	Verdickung
stretching	extensible	streckend
stroke	trait	Strich
stroke thickness	épaisseur de trait	Strichdicke
swash	sortie gracile, paraphe	Auszug, Zierstrich

English	French	German
swash character	lettre ornée	Zierbuchstabe, Schwungbuchstabe
symbol	symbole	Signet
tabular setting	composition de tableau	Tabellensatz
tail	queue	Abschwung, Schwanz
tangent point	point de tangente	Tangentenpunkt
terminal	sortie	Endung
text setting	composition de texte	Textsatz
text type, text typeface	caractères de textes	Brotschrift, Textschrift, Werkschrift
total width	chasse	Dickte
touching	d'acollage	berührend
touching table	table de chasse reduites	Berührungstabelle
traditional	traditionelle	traditionell
type	style, caractère	Schrift
typeface	oeil de caractère	Schriftbild
typeface family	famille des caractères	Schriftfamilie
type height	hauteur des caractères	Schrifthöhe
type size	corps	Schriftgrad
type style	style de caractère	Schriftstil
upright	droite	gerade(stehend)
up-stroke	delié	Aufstrich
version	graisse, version	Schriftschnitt, Version
vignette	vignette	Vignette
weight	graisse, ensemble	Fettegrad, Schriftschnitt
white space	espace blanc	Zwischenraum

English	French	German
width	chasse	Weite
width table	table de chasse	Dicktentabelle
word space	espace entre des mots	Wortzwischenraum
x-height	hauteur des minuscules	Minuskelhöhe

Appendix G
Data structure for typefaces

Fonts can be stored digitally by a vast number of different methods, as we have seen. These often very different sorts of data lead to different formats. Each format presents the image information of a letter in a different manner. Despite this it is possible to find a uniform structure for the data on a data carrier. In the following, we describe the structure as used by URW. This description goes for all fonts supplied irrespective of format. The formats themselves are described individually in the appropriate appendices I to Q.

1. Data carrying media for font data

1.1 Magnetic tape, 9 track, 800 or 1600 bpi writing density. This is the data carrier recommended by URW as standard because of its many advantages (price, large capacity, mechanical tolerance, wide availability of reading equipment, reliability).

1.2 Diskette (floppy disk), soft sectored, single or double density, written on an IBM PC or a MacIntosh.

1.3 Standard disk cartridges compatible with the DEC computer systems (RL01, RL02, Phoenix, CDC etc.) can be supplied.

1.4 Other data carriers, e.g. TU58 cassettes or paper tapes can also be supplied.

All data carriers are written sequentially, independent of the operating system. The client therefore has direct access to the data to allow further processing using a simple reading program. Several fonts can be supplied on either one or more data carriers. A font usually consists of less than 256 characters, it may however consist of a maximum of 32,000 characters. On the other hand a font may consist of a maximum of 32,000 records of 2048 words in length, i.e. 128 megabytes.

2. The label on data carriers

Every single data carrier belonging to a font has a label of 40 words length. This label is written completely in ASCII and provides an individual identification of the data carrier, also within each font

delivery. It currently includes information as to the origin of the data carrier, the time of its generation, an index number for the data carriers within one font delivery, and details as to the record length of all subsequent data records.
A label has the following form:

Word	Meaning
1	Length of label: **40**
2–20	Origin of data media e.g. **URW_IKARUS_V3.1_VAX_11/750_VMS**
21–30	Start of generation of this data carrier e.g. **17_JAN_85_17:31**
31–35	Data carrier index e.g. **VOL_0**
36–40	Length of physical record in words e.g. **_BLK_2048** If record length is given as 0 then the data records of this data carrier have variable lengths.

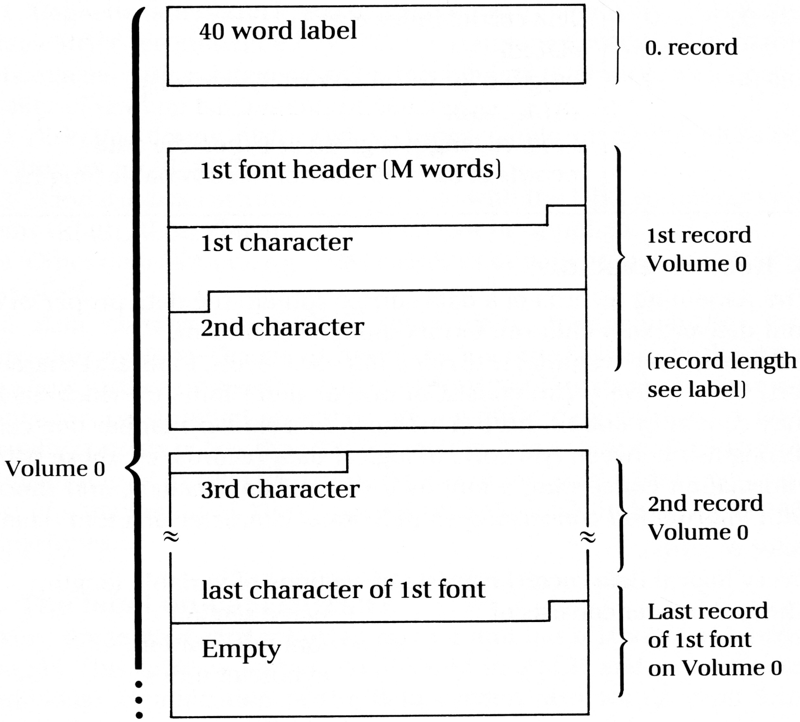
3. Record structure

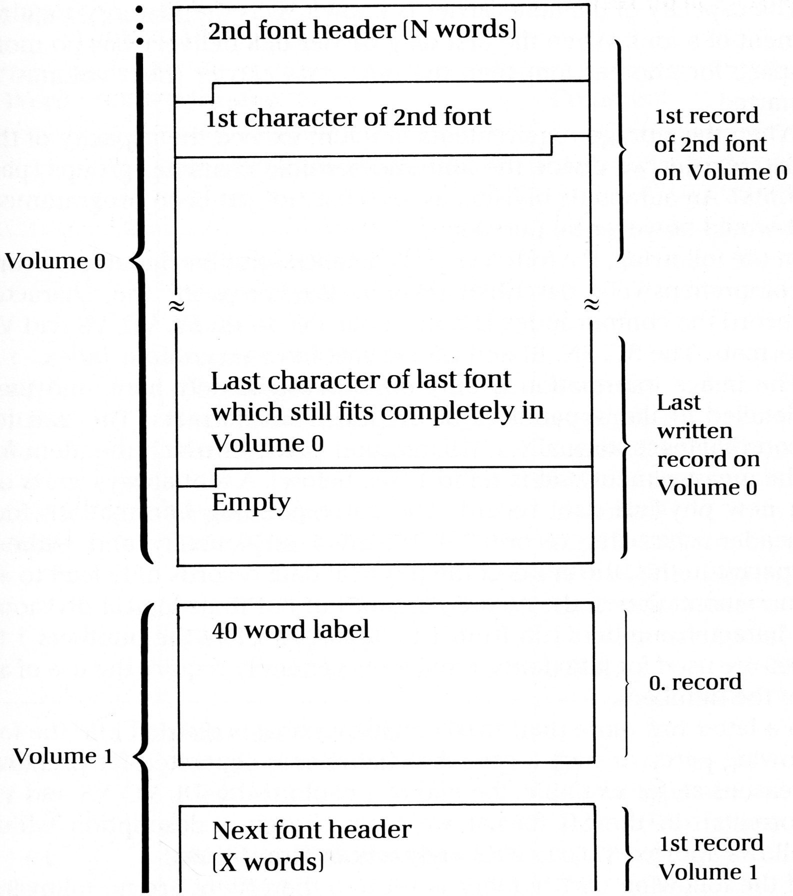
The remaining records of a data carrier contain the data proper of a font delivery in a uniform, format independent form.
A font delivery (volume) is divided into two levels, fonts and characters, i.e. a delivery can consist of one or more fonts of which each may consist of one or more characters. In a similar manner one can distinguish between two sorts of logical data records, i.e. those with information concerning a font as a whole (font header), and those with information concerning an individual character of a font (character records).
Every logical data record consists of sections of variable length:
The font header consists of

- name section
- font information
- character index;

the character record consists of
- name section
- setting information
- contour index
- image information.

Every logical data record and every part thereof starts with a data word which contains the length of the record or the section in words. **We quantify and describe the data in words (16 bit)!**
The data is recorded in so-called physical records. At URW we use a record length of 2048 words for disk storage and magnetic tape storage. A font always starts with a new physical data record. A font delivery has the following structure:


40 word label
0. record
1st font header (M words)
1st character
2nd character
1st record
Volume 0
(record length
see label)
Volume 0
3rd character
2nd record
Volume 0
last character of 1st font
Empty
Last record
of 1st font
on Volume 0


2nd font header (N words)
1st character of 2nd font
1st record of 2nd font on Volume 0
Volume 0
Last character of last font which still fits completely in Volume 0
Last written record on Volume 0
Empty
40 word label
0. record
Volume 1
Next font header (X words)
1st record Volume 1

The capacity of the data carrier is known, as is the memory requirement of a font. When the first data carrier of a delivery has no more space for another font then the next data carrier (next volume) is started.

When the storage requirements of a font exceed the capacity of the data carrier we divide the font into sensible character groups (part fonts). An automatic division as such has not yet been programmed, it would however be possible.

In the following, the font header is detailed and the character record comprehensively described. Within the terms of the character record the contour index is only applicable to IK, DI, VC, VS and VE formats. The SC, SN, BI and GS formats have no contour index.

The image information is only described generally here, and then detailed in the appendices of the individual formats. The unit for coordinates is normally 1/100 mm or 1 pixel, in which the ident for the measurement unit is set to 1 (see below). A font always starts on a new physical data record. The corresponding information (font header, character records) is recorded sequentially and without spaces. In this, the limits of the physical data records only lead to an incrementation of the record counter but not to its logical division.

Character numbers run from 1 to 32,000. At URW the numbers 1 to 999 are used for latin fonts. Kanji fonts generally require the use of all of the numbers.

If a letter has more than 10,000 digitizations it is divided into the following parts. In such a case the character is separated for practical reasons at, for example, the end of a contour (IK, DI, VC, VS and VE formats). In the SC format we have chosen a description which allows approx. 32,000 × 2048 digitizations (transitions).

If the following part number is set to 0 then there are no following parts. The numbers of the following parts are selected automatically from unused character numbers above 999.

4. Font header

Word	Meaning	Comment
1	Length of font header in words	$=1+I+J+L+M$
	Name section	
2	Length of name section in words	(I)
3	Number on URW list	
4–9	**File name**	6 words
10–49	Font name in ASCII	40 words
50	Format ident of data	e.g. IK, DI, G1...G4, VC, ...
51–53	Production date	3 words
54–56	Date of last change	e.g. 16, 6, 85 for 16th of June 1985. Currently (1985) I has the value 55 at URW.
	Font information	
$I+2$	Length of font data in words	(J)
$I+3$	Ident of font	$=1$ for typeface $\neq 1$ for IG structure
$I+4$	**Number of characters**	
$I+5$	Cap height	given in units, usually 1/100 mm, or in pixels
$I+6$	Body size	
$I+7$	x-height	
$I+8$	Distance of base line from lower body line	
$I+9$	Line distance for composition	
$I+10$	Stroke thickness	
$I+11$	Italic angle	in 1/10 degrees

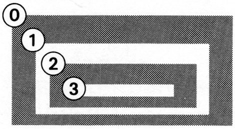
Word	Meaning	Comment
I+12	Optimum size for composition in Didot points	e.g. 12 p
I+13	Average character width (based on international character frequency)	in 1/100 mm
		At URW (1985) J currently has the value 12.
	Hierarchy section	
I+J+2	Length of hierarchy section in words	(L) =1 for fonts ≠1 for IG graphics (see appendix H)
	Character index	
I+J+L+2	Length of character index in words	(M)
I+J+L+3	**Pointer to last written physical record (=length of font in physical records)**	
I+J+L+4	Pointer to last written word of last record	
I+J+L+5	Number of first character	3 words for one character
I+J+L+6	Pointer to record in this font which contains the start of the first character	
I+J+L+7	Pointer in this record to the word which is the first word of the corresponding character record	

Word	Meaning	Comment
I+J+L+8	Number of second character etc.	
. . .	. . .	
I+J+L+M+1	Pointer to the word of the character record where the last character starts	

5. Character record

Word	Meaning	Comment
	Length of first character	2 + N1 + N2 + N3 + M
1	in records (length = 2048 words)	
2	in words	
	Name section	
3	Length of name section in words	N1 (currently = 3)
4	Character number	1,2...999 At URW currently character numbers are 1,2...999. Character names (in ASCII) are predefined by separate character layouts (e.g. keyboard layouts).
5	Character number of following part	Following parts have numbers of 1000...32,000. 0 means there is no following part.
	Setting information	
N1 + 3	Length of setting information	N2 (currently = 12)
N1 + 4	Character sort	1 = letter 2 = logo/signet 3 = line graphic 4 = frame
N1 + 5	**Number of digitizations**	
N1 + 6	**Total width (T)**	given in units

Word	Meaning		Comment
N1 + 7	Left side bearing (L)		given in units T = L + W + R
N1 + 8	Width (W)		
N1 + 9	Right side bearing (R)		
N1 + 10	X minimum	bounding box	given in units
N1 + 11	X maximum		
N1 + 12	Y minimum		
N1 + 13	Y maximum		
N1 + N2 + 2	Unit size (definition of the unit)		= 1 ≙ unit is 1/100 mm or ≙ 1 pixel **(normal)** = 2 ≙ unit is 2/100 mm = 3 etc. When the unit is set to 2, for example, one must multiply the coordinates prior to the use of the character by a factor of 2.
	Contour index		
	Length of contour index		N3 = N4 × 2048 + N5
N1 + N2 + 3	in records (N4)		
N1 + N2 + 4	in words (N5)		
N1 + N2 + 5	Record pointer,		
N1 + N2 + 6	Word pointer of first contour relative to start of image information. The start of the image information relative to character data record is **3 + N1 + N2 + N3.**		

Word	Meaning	Comment
N1 + N2 + 7	Sense of rotation of first contour	− 1 = clockwise 0 = open contour + 1 = anti-clockwise
N1 + N2 + 8	Identifier for nesting hierarchy	0 = outer contour 1st order 1 = inner contour 1st order 2 = outer contour 2nd order 3 = inner contour 2nd order 4 = etc. 
N1 + N2 + 9	Color inside contour	0 = transparent 1 = black, etc.
N1 + N2 + 10	Number of digitizations of 1st contour	
N1 + N2 + 11	Record pointer to 2nd contour	
N1 + N2 + 12	Word pointer	6 words per contour
N1 + N2 + 13	Sense of rotation	
N1 + N2 + 14	Nesting identification	
N1 + N2 + 15	Color	
N1 + N2 + 16	Number of digitizations	
N1 + N2 + 17	Record pointer to 3rd contour	
. . .	. . .	
N1 + N2 + N3 + 2	Number of digitizations of last contour of first character	

Word	Meaning	Comment
	Image information	
N1 + N2 + N3	Length of data	M = N6 × 2048 + N7
+3	in records (N6)	
+4	in words (N7)	
+5	Storage of image information of first character of this font (in 16 bit words)	
+6	This can be followed by	
+7	either IK, DI, VC, VS, VE, SC, SN, BI or GS formats, see appendices I to Q.	
.	.	
≈ .	≈ .	≈ ≈
.	.	
N1 + N2 + N3 + M + 2	Final word of image information of first character of this font	
... + 3	Length of 2nd character in records	
.	.	
≈ .	≈ .	≈ ≈
.	.	
xyz	Last word of image information of last character of this font	See font header

Appendix H
Data structure for graphics: IG format

Graphics are created doing design jobs at computer aided graphic work stations. They can take the form of an IK job in a display lettering system, of an advertisement in a page make-up or of a design system for layouts of magazine pages. The storage of graphics is the same as for fonts, i.e. the data is physically divided into records of fixed length which cause no other logical division of the data.

Graphics can also be generated by the LINUS system for the automatic recording of black and white images and the output of their IK digitizations.

Any graphic can be converted by programs into a character of a font and vice versa. When storing a graphic as a character the hierarchy information is lost, when storing a character as a graphic only a basic hierarchy is automatically generated.

1. Data carrying media for graphic data

1.1 Magnetic tape, 9 track, 800 or 1600 bpi density. This is the data carrier recommended by URW as standard because of its many advantages (price, large capacity, mechanical tolerance, wide availability of reading equipment, reliability).

1.2 Diskette (floppy disk), soft sectored, single or double density, written on an IBM PC or a MacIntosh.

1.3 Standard disk cartridges compatible with the DEC computer systems (RL01, RL02, Phoenix, CDC etc.) can be supplied.

1.4 Other data carriers, e.g. TU58 cassettes or paper tapes can also be supplied.

All data carriers are written sequentially, independent of the operating system. The client therefore has direct access to the data to allow further processing using a simple reading program. Several graphics can be supplied on either one or more data carriers. A graphic usually consists of less than 256 characters, it may however consist of a maximum of 32,000 characters. On the other hand a graphic may consist of a maximum of 32,000 records of 2048 words in length, i.e. 128 megabytes.

2. The label on data carriers

Every single data carrier belonging to a graphic has a label of 40 words length. This label is written completely in ASCII and provides an individual identification of the data carrier, also within each graphic delivery. It currently includes information as to the origin of the data carrier, the time of its generation, an index number for the data carriers within one graphic delivery, and details as to the record length of all subsequent data records.

A label has the following form:

Word	Meaning
1	Length of label: **40**
2–20	Origin of data media e.g. **URW_IKARUS_V3.1_VAX_11/750_VMS**
21–30	Start of generation of this data carrier e.g. **17_JAN_85_17:31**
31–35	Data carrier index e.g. **VOL_0**
36–40	Length of physical record in words e.g. **_BLK_2048** If record length is given as 0 then the data records of this data carrier have variable lengths.

3. Record structure

The remaining records of a data carrier contain the data proper of a graphic delivery in a uniform, format independent form.

A graphic delivery (volume) is divided into two levels, graphics and characters, i.e. a delivery can consist of one or more graphics of which each may consist of one or more characters. In a similar manner one can distinguish between two sorts of logical data records, i.e. those with information concerning a graphic as a whole (graphic header) and those with information concerning an individual character of a graphic (character records).

Every logical data record consists of sections of variable length:

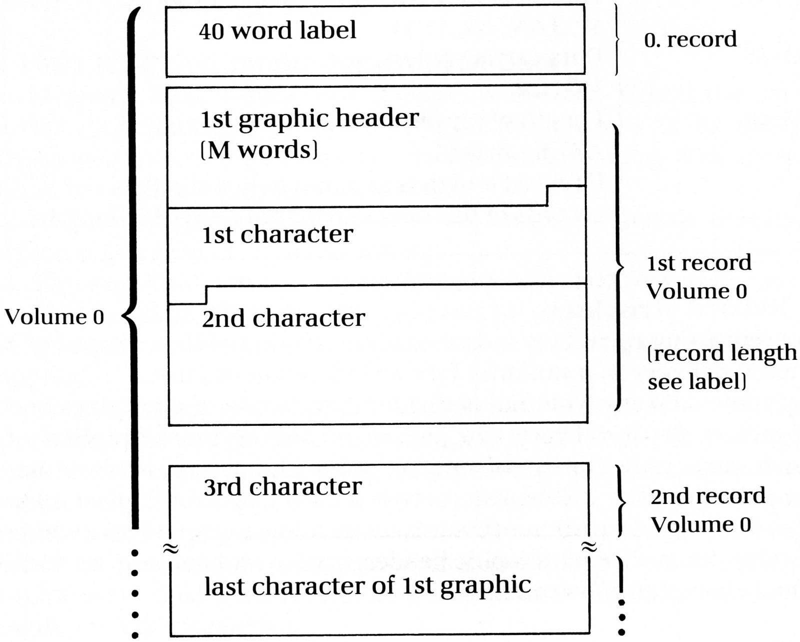
The graphic header consists of – name section
– hierarchy section;

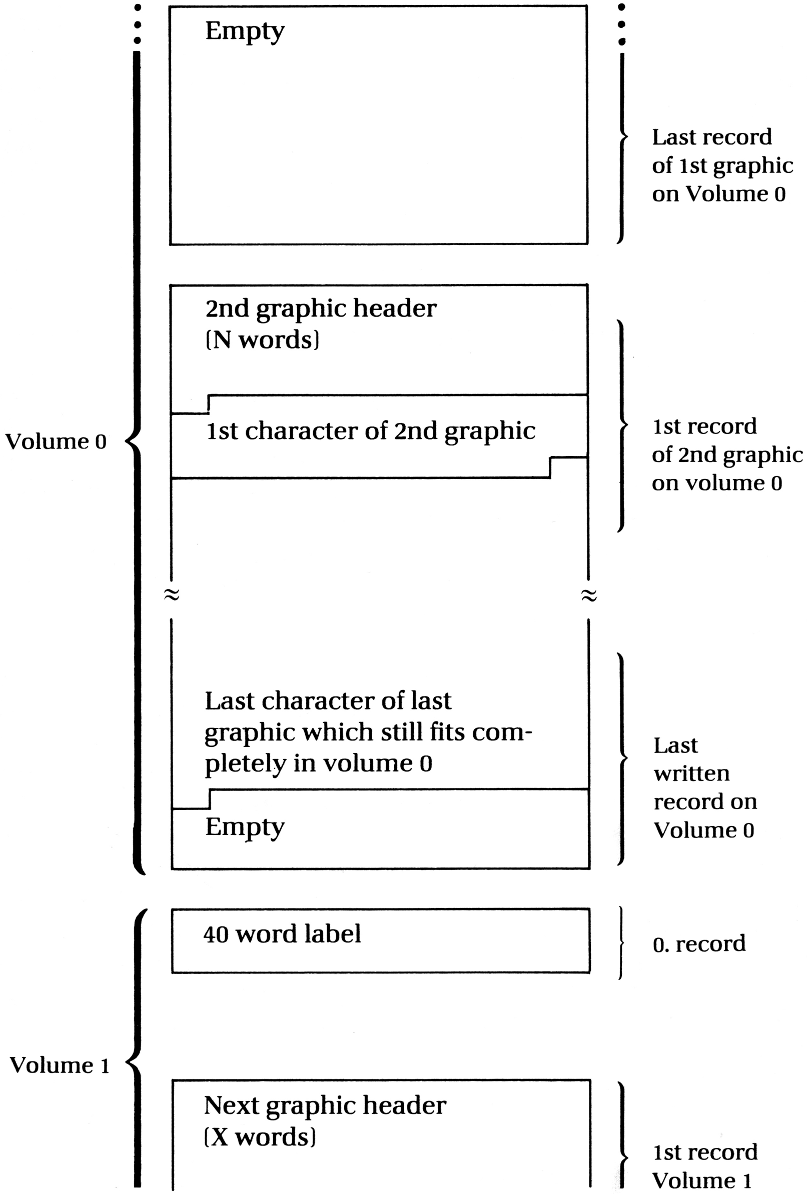
The character data record consists of – name section
– setting information
– contour index
– image information.

Every logical data record and every part thereof starts with a data word which contains the length of the record or the section in words.

We quantify and describe the data in words (16 bit)!

The data is recorded in so-called physical records. At URW we use a record length of 2048 words for disk storage and magnetic tape storage. A graphic always starts with a new physical data record. A graphic delivery has the following structure:


40 word label
0. record
1st graphic header
(M words)
1st character
2nd character
1st record
Volume 0
(record length
see label)
Volume 0
3rd character
2nd record
Volume 0
last character of 1st graphic


Empty
Last record of 1st graphic on Volume 0
2nd graphic header (N words)
1st character of 2nd graphic
1st record of 2nd graphic on volume 0
Volume 0
Last character of last graphic which still fits completely in volume 0
Empty
Last written record on Volume 0
40 word label
0. record
Volume 1
Next graphic header (X words)
1st record Volume 1

The capacity of the data carrier is known, as is the memory requirement of a graphic. When the first data carrier of a delivery has no more space for another graphic then the next data carrier (next volume) is started.

When the storage capacity requirement of one graphic exceeds the capacity of the data carrier we divide the graphic into sensible character groups (part graphics). An automatic division as such has not yet been programmed, it would however be possible.

In the following, the graphic header is detailed and the character record clearly described. Within the terms of the character record the contour index is only applicable to IK, DI, VC, VS and VE formats. The SC, SN, BI and GS formats have no contour index.

The image information is only described generally here, and then detailed in the appendices of the individual formats. The unit for coordinates is normally 1/100 mm or 1 pixel, in which the ident for the measurement unit is set to 1 (see below). A graphic always starts at the beginning of a physical data record. The corresponding information (graphic header, character records) is recorded sequentially and without spaces. In this, the limits of the physical data records only lead to an incrementation of the record counter but not to its logical division.

If a character has more than 10,000 digitizations it is divided into the following parts. In such a case the character is separated for practical reasons at, for example, the end of a contour (IK, DI, VC, VS and VE formats). In the SC format we have chosen a description which allows approx. 32,000 × 2048 digitizations (transitions).

If the following part number is set to 0 then there are no following parts. The numbers of the following parts are selected automatically from unused character numbers above 999.

The IG format has been designed conceptually in such a way that with the right preconditions it can also be read from disk and correctly interpreted by programs which can process the IK format. In this sense the IG format is only an expanded version of the IK format.

A part of the utility data of the knots is ignored then, i.e.:

- The coordinate system of all knots must have the same origin and may not be rotated respective to each other.
- The color of the knots is ignored.

4. Graphic header

The graphic header has the same structure as a font header. However, the hierarchy section is now fully defined. It includes data on the characters respective to superimposed levels, e.g. lines, blocks or layers. The character index is dropped.

4.1 Description of the hierarchy

The image information is divided into the following hierarchy (see figure 1):

- Graphic (advert., article, job)
- Layer
- Block (column)
- Line
- Character

- Contour (in the contour index of the character)

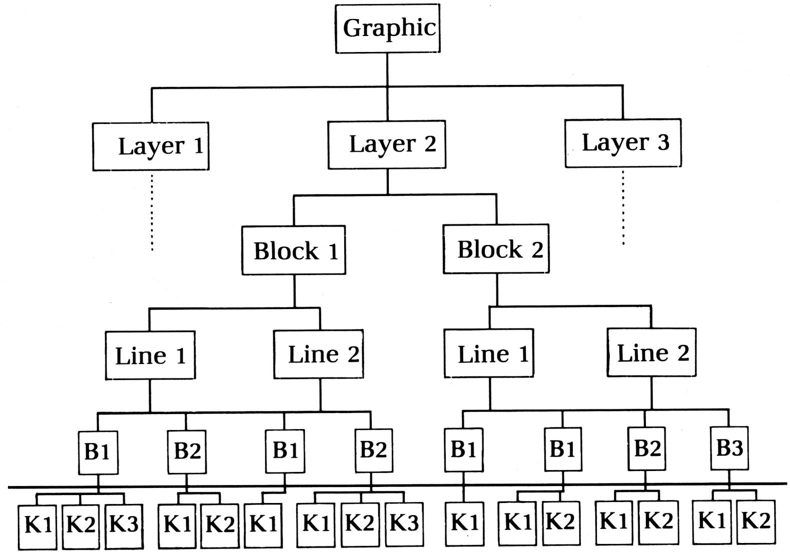

Graphic
Layer 1
Layer 2
Layer 3
Block 1
Block 2
Line 1
Line 2
Line 1
Line 2
B1
B2
B1
B2
B1
B1
B2
B3
K1
K2
K3
K1
K2
K1
K1
K2
K3
K1
K1
K2
K1
K2
K1
K2

Figure 1

Bn identifies characters and **Kn** the contours. The image information proper is contained in the IK, DI, VC, VS, VE or SC format of the digitized points of the contours or scanlines respectively.

Knots are located at those points where the hierarchy tree divides. There are therefore graphic, layer, block, line and character knots. Those knots related to another knot but lying one step higher are known as **fathers.** Those knots at the same hierarchy level related to one father are known as **brothers.** A succession is then defined. This is created during the work session in which a graphic is prepared. The chronological succession is also the **order succession.** In a hierarchy tree, left is defined as earlier and right defined as later.

Every knot can therefore have left and right brothers. Those knots related to a knot but lying one step lower are known as **sons.** There are first and last sons.

In figure 1 lines 1 and 2 are brothers and they have block 1 as their father whereas line 1 from block 2 is not their brother since they only have the grandfather (level 2) in common with 1 and 2.

In the IG format every knot contains information concerning the element as a whole, which the knot represents, over the whole line.

The following information is stored on each knot:

- pointer information
- utility data.

4.2 Describing the knots

Knots are allocated to graphics, layers, blocks, lines and characters. They contain the following pointers to other knots:

	e.g. for line 2 block 2 (figure 1)
pointer – to itself (sequential number)	line 2
– to the father	block 2
– to the left brother	line 1
– to the right brother	missing
– to the first son	B(character) 1
– to the last son	B(character) 2

In this manner one may move both from one hierarchy step to another as well as within one hierarchy level. Some movements require detours, in full one can only reach the "cousins" by passing through the grandfather, i.e. via an "ancestor", and the "penultimate son" can only be arrived at via a detour over the first son. In many cases pointers do not point to a knot, and the "first" of course does not have a left brother. In general one may say that each knot (except for the graphic) has a father and at least one son. **Utility data** of a constant length is allocated to every knot.

Utility data

- **Factor**
  One may state a factor for sizing (enlarging/reducing). 1000 is a factor 1.000, 500 the factor 0.5. It first comes into operation in the output of the complete part tree of the hierarchy to which the knot belongs, and on the knot itself. The sizing can only take place as seen from the father.
- **Position of coordinate system relative to father (X and Y coordinates)**
  The coordinate origin can be moved relatively to the father. The values are given in double words and respective to the coordinate system of the father.
- **Angle of rotation relative to father**
  Details of the angle of rotation are given in positive mathematical figures. The rotation axis is the coordinate origin of the knot. The angular details are given in 1/100 degree (e.g. 9000=90 degrees). The rotation can only be realized respective to the coordinate system of the father.
- **Size of bounding box (XMIN, XMAX, YMIN, YMAX)**
  relative to the coordinate origin of the knot.
  The data is given in double words.
  In order to be able to find characters, lines etc. via, for example, the geometrical position of one of their IK points, it is useful to know the boundaries of an element via the data of the bounding box. It is quite possible that rectangles of this sort within the various elements of the same hierarchy level can overlap (see figure 3).

- **Color**
  The color is an additional characteristic, which can be important when cutting foils or exposing films. Since each knot can be allocated a color there is the possibility that one and the same element can have more than one color, for example, a “red” line in a “black” block. This line then has red as well as black color. This however leads to no conflict since either the color is ignored or only one color at a time is cut in the foil or exposed.

By changing the utility data and not tampering with the image data, the following may be carried on with whole lines, blocks etc.:
- sizing
- shifting
- rotating or coloring.

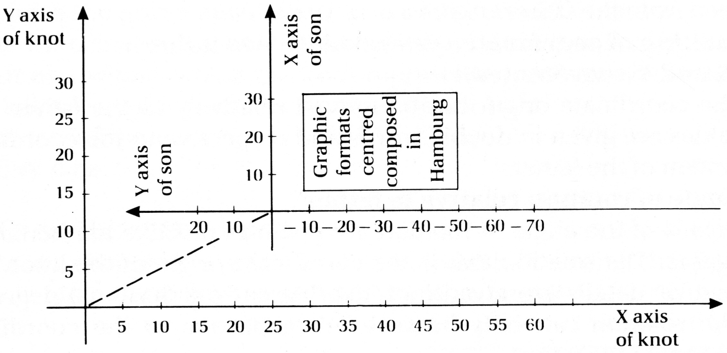
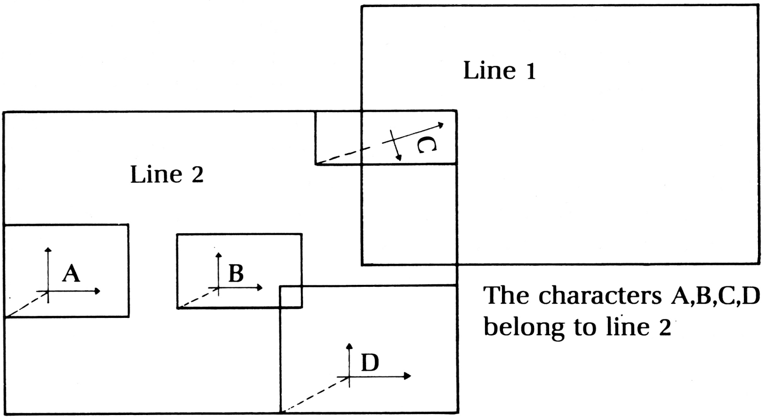

Y axis of knot
30
25
20
15
10
5
X axis of son
30
20
10
Graphic formats centred composed in Hamburg
Y axis of son
20 10
– 10 – 20 – 30 – 40 – 50 – 60 – 70
5 10 15 20 25 30 35 40 45 50 55 60
X axis of knot

Figure 2

In this example the utility data of the son has the following values:
- factor is 0.5 (see axis designation)
- position of coordinate system is (25, + 13)
- angle of rotation 9000 (= 90.00 degrees)
- size of bounding box XMIN = 5 XMAX = 32
  YMIN = – 50 YMAX = – 8.



The characters A,B,C,D belong to line 2

Bounding boxes
Figure 3

4.3 Guidelines for programming

When the data is stored in the working area, only the pointers and utility data at the knots are continuously updated.

New additional data, e.g. knots or new image information, is stored at the end of the corresponding data section, and old obsolete data is initially left, and later deleted during reorganization.

The reorganization of the data, i.e. the deletion of obsolete information and the reordering of the pointers, is something which should take place automatically:

- as required (when the overflow of data buffers is possible), but at least
- prior to archiving to disk.

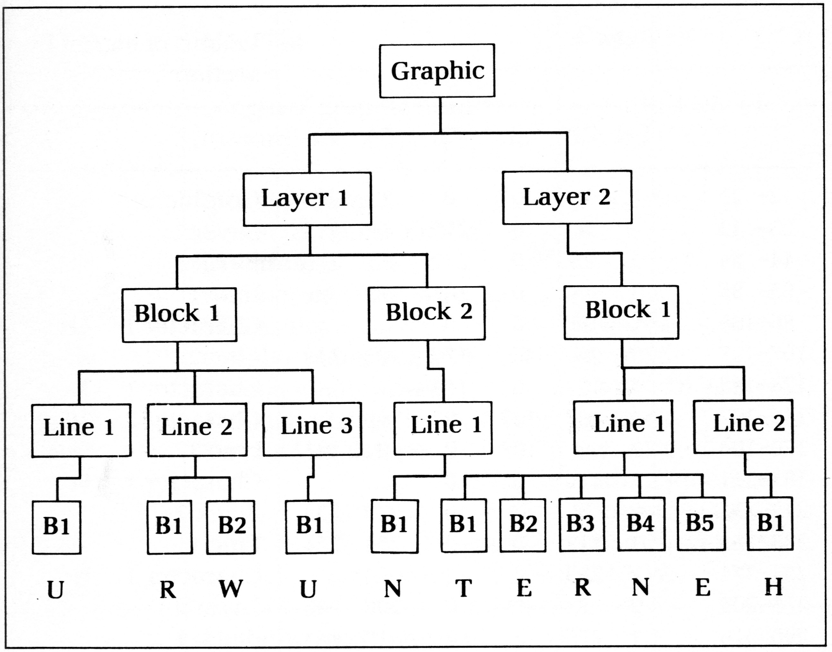
The data at the knots is of a fixed length (21 words).

The knots within the same hierarchy levels should be ordered in ascending succession. This **does not** however necessarily mean that knots with sequentially ascending numbers are logically related. The relationships (e.g. to the same father) are uniquely specified by the pointers.

4.4 Summary of knot information

Word		Meaning	Comment
1	Pointer	Sequential number	Within the level, the sons of each father are counted
2		Pointer to father	
3		Pointer to left brother	
4		Pointer to right brother	
5		Pointer to first son	
6		Pointer to last son	
		On the character level in the words 5 and 6 instead:	Utility data
		5 Pointer to physical record which contains the start of the character	Pointer Utility data
		6 Pointer to the word in the record where the character record starts.	
7	Utility data	Factor	Operates as multiplier on sons, grandsons etc.
8–9		X position	Measured in units, relative to father coordinate system
10–11		Y position	
12		Angle of rotation	Around the origin of father
13–14		X minimum	See comment on (X,Y) position
15–16		X maximum	
17–18		Y minimum	See comment on (X,Y) position
19–20		Y maximum	
21		Color	e.g. 0 = transparent 1 = black

4.5 Example of pointer information in hierarchy section


Graphic
Layer 1
Layer 2
Block 1
Block 2
Block 1
Line 1
Line 2
Line 3
Line 1
Line 1
Line 2
B1
B1
B2
B1
B1
B1
B2
B3
B4
B5
B1
U
R
W
U
N
T
E
R
N
E
H

A total of 23 knots results. The first knot stored in the data is the graphic knot.

We abbreviate as follows:

LN = Sequential number
ZF = Pointer to father
ZL = Pointer to left brother
ZR = Pointer to right brother
ZA = Pointer to first son
ZZ = Pointer to last son

Word	Meaning						Comment	
1	484						Length of hierarchy section	
	LN	ZF	ZL	ZR	ZA	ZZ		
2– 22	1	0	0	0	23	275	Graphic	
23– 43	1	2	0	275	44	212	Layer 1	
44– 64	1	23	0	212	65	170	Block 1	
65– 85	1	44	0	107	86	86	Line 1	
86–106	1	65	0	0	...	...	Character 1	U
107–127	2	44	65	170	128	149	Line 2	
128–148	1	107	0	149	...	...	Character 1	R
149–169	2	107	128	0	...	...	Character 2	W
170–190	3	44	107	0	191	191	Line 3	
191–211	1	170	0	0	...	...	Character 1	U
212–232	2	23	44	0	233	233	Block 2	
233–253	1	212	0	0	254	254	Line 1	
254–274	1	233	0	0	...	...	Character 1	N
275–295	2	2	23	0	296	296	Layer 2	
296–316	1	275	0	0	317	443	Block 1	
317–337	1	296	0	443	338	422	Line 1	
338–358	1	317	0	359	...	...	Character 1	T
359–379	2	317	338	380	...	...	Character 2	E
380–400	3	317	359	401	...	...	Character 3	R
401–421	4	317	380	422	...	...	Character 4	N
422–442	5	317	401	0	...	...	Character 5	E
443–463	2	296	317	0	464	464	Line 2	
464–484	1	443	0	0	...	...	Character 1	H

5. Graphic header

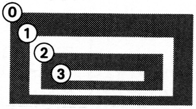
Word	Meaning	Comment
1	Length of graphic header in words	$=1+I+J+K+L$
	Name section	
2	Length of name section in words	(I)
3	Number on URW list	
4–9	**File name**	6 words
10–49	Graphic name in ASCII	40 words
50	Format ident of data	e.g. IK, DI, G1, VC, ...
51–53	Production date	3 words
54–56	Date of last change	e.g. 16, 6, 85 for 16th of June 1985. Currently (1985) I has the value 55 at URW.
	Graphic information	
$I+2$	Length of graphic data in words	$(J=2)$
$I+3$	Ident of structure	2 for IG structure
	Hierarchy section	
$I+J+2$	Length of hierarchy section in words	(K)
$I+J+3$ . . . . $I+J+23$	Knot for the graphic	(21 words)

Word	Meaning	Comment
I+J+24 . . . . I+J+44	Knots of 1st layer	(21 words)
I+J+45 . . . I+J+65 . . .	Knots	if present
I+J+K+1	Last knot	(21 words)
I+J+K+2	**Character index** Length of character index in words	(L) =1, because contained in knot data

6. Character record

Word	Meaning	Comment
1 2	Length of first character in records (length = 2048 words) in words	2 + N1 + N2 + N3 + M
	Name section	
3	Length of name section in words	N1 (currently = 9)
4	Character number	1,2...999 At URW currently character numbers are 1,2...999. Character names (in ASCII) are predefined by separate character layouts (e.g. keyboard layouts).
5	Character number of following part	Following parts have numbers of 1000...32,000. 0 means there is no following part.
6–11	File name	6 words (as font name)
	Setting information	
N1 + 3	Length of setting information	N2 (currently = 8)
N1 + 4	Character type	1 = letter 2 = logo/signet 3 = line 4 = frame

Word	Meaning	Comment
N1+5	**Number of digitizations**	
N1+6	**Total width (T)**	given in units T=L+W+R
N1+7	Left side bearing (L)	
N1+8	Width (W)	
N1+9	Right side bearing (R)	
N1+N2+2	Unit size (definition of the unit)	=1 ≙ unit is 1/100 mm or ≙ 1 pixel **(normal)** =2 ≙ unit is 2/100 mm =3 etc. When the unit size is set to 2 for example, one must multiply the coordinates prior to use of character by a factor of 2.
	Contour index	
	Length of contour index	N3=N4×2048+N5
N1+N2+3	in records (N4)	
N1+N2+4	in words (N5)	
N1+N2+5	Record pointer,	
N1+N2+6	Word pointer of first contour relative to start of image information. The start of image information relative to character data record is **3+N1+N2+N3.**	
N1+N2+7	Sense of rotation of first contour	−1=clockwise 0=open contour +1=anti-clockwise

Word	Meaning	Comment
N1 + N2 + 8	Identifier for nesting hierarchy	0 = outer contour 1st order 1 = inner contour 1st order 2 = outer contour 2nd order 3 = inner contour 2nd order 4 = etc. 
N1 + N2 + 9	Color inside contour	0 = transparent 1 = black etc.
N1 + N2 + 10	Number of digitizations of 1st contour	
N1 + N2 + 11	Record pointer to 2nd contour	
N1 + N2 + 12	Word pointer	6 words per contour
N1 + N2 + 13	Sense of rotation	
N1 + N2 + 14	Nesting identification	
N1 + N2 + 15	Color	
N1 + N2 + 16	Number of digitizations	
N1 + N2 + 17	Record pointer to 3rd contour	
. . .	. . .	
N1 + N2 + N3 + 2	Number of digitizations of last contour of first character	

Word	Meaning	Comment
	Image information	
N1 + N2 + N3	Length of data	$M = N6 \times 2048 + N7$
+ 3	in records (N6)	
+ 4	in words (N7)	
+ 5	Storage of image information of first character of this graphic (16 bit words).	
+ 6	This can be done by using	
+ 7	either IK, DI, VC, VS, VE, SC, SN, BI or GS formats, see appendices I to Q.	
.	.	
≈ .	≈ .	≈
.	.	
N1 + N2 + N3 + M + 2	Final word of image information of first character of this graphic	
N1 + N2 + N3 + M + 3	Length of 2nd character in records	
.	.	
≈ .	≈ .	≈
.	.	
XYZ	Last word of image information of last character of this graphic	

Appendix I
Description of the IK format

1. Structure of an IK font

For the structure of an IK typeface font see the structure as described in appendix G.

2. Description of the IK format

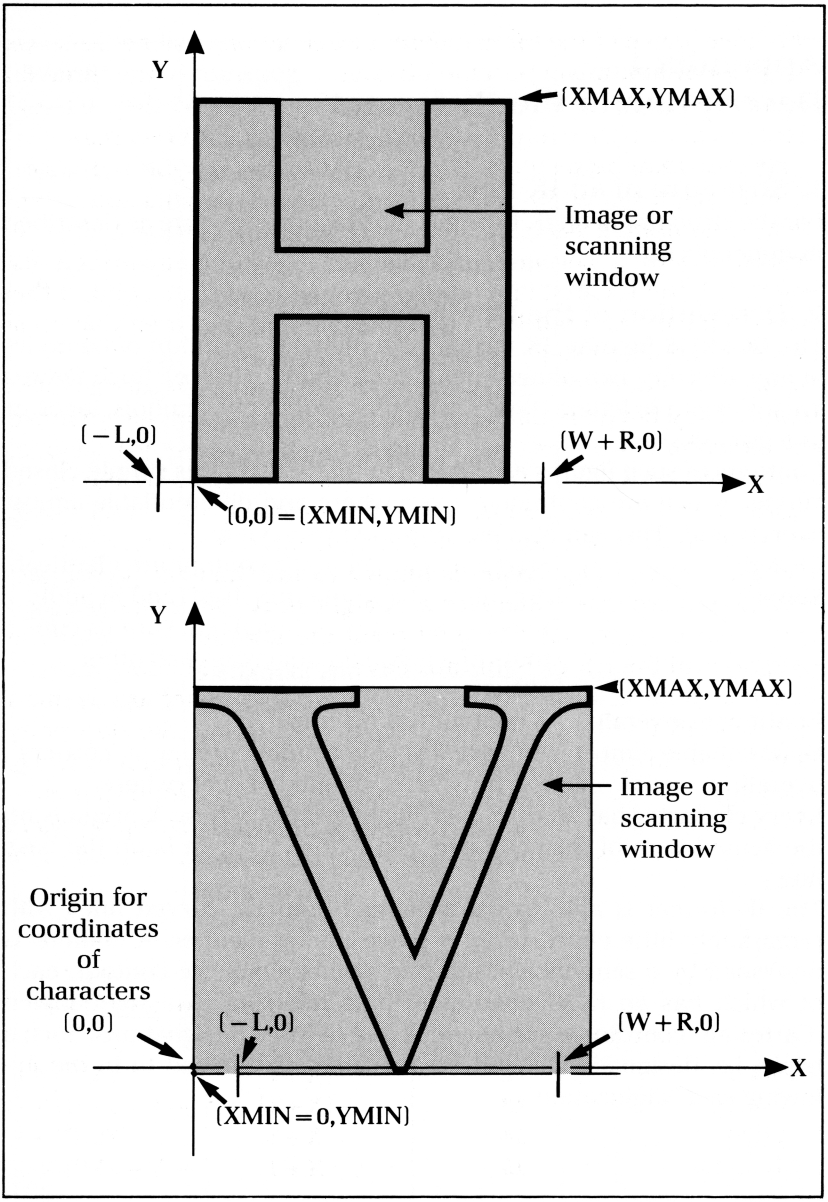
The **IKARUS format** (IK format) is a digital description of contours of any arbitrary two dimensional plane figure (surface). Such figures are for example letters (type characters), company symbols, logos or line graphics.

Contours of such figures are known in mathematics as simple closed curves, which are continuous everywhere and differentiable almost everywhere. This can also be expressed by saying:

Closed:	Start and end point of a contour are identical.
Simple:	A contour does not cross itself (and in addition, as can easily be imagined, various contours of a figure do not cross each other either).
Continuous overall:	A contour has no "gaps".
Differentiable almost overall:	An edge has only a finite number of "corners", it is thus "smooth" almost everywhere.

Every character has its own coordinate system, whose X origin is on the X minimum of the character and whose Y origin is on the base line.

The IK format is able to describe such general curved lines with remarkably little effort, i.e. in a space saving manner. A contour is described by a sequence of selected points along the contour, each of which has an (X,Y) coordinate pair referring to a right-angled (Cartesian) coordinate system, plus one of three designations. Such a triple, i.e. designation, X and Y coordinate, is referred to in the following as a "digitization".


Y
(XMAX,YMAX)
Image or scanning window
(−L,0)
(W+R,0)
X
(0,0) = (XMIN,YMIN)
Y
(XMAX,YMAX)
Image or scanning window
Origin for coordinates of characters (0,0)
(−L,0)
(W+R,0)
X
(XMIN = 0,YMIN)

The importance of the three different designations will be discussed in the following. It will become obvious why not only the three different sorts of digitization are necessary, but also why they are sufficient to comprehensively describe the above named contours.

A contour may be pictured as a succession of straight and curved contour segments or, in brief, as a sequence of straights and curves. Two neighbouring straights or two neighbouring curves always, by definition, form a "corner" where they meet. Where they meet is also where we find the first kind of digitization; the corner point. If they were to form a smooth transition into one another then one could describe them as a single straight or a single curve.

Digitization points of the second kind are found on curves; curve points. They have the function of "aid points" and are set whenever the direction of the curve has changed by approximately 30 degrees. In addition, all local X and Y values at the extrema of contours are digitized with curve points. Thus, for example, in a circle these extrema would be the outermost left, right, upper and lower points.

The third sort of digitization is known as the "tangent point". Tangent points are used wherever a straight runs "tangentially" into a curve or vice versa. At a tangent point the straights or curves running in from the left or right thus have the same direction.

In order to be able to identify the beginnings of contours within a figure the IK format has a fourth sort of digitization, the start point. In order to "properly" identify a start point, the start point to is digitized again at the end of a contour with its normal identification.

The values of X and Y coordinates are limited to an upper value 32,767. The various identifications in the IK format are derived as follows:

Point type	Internal ident.	Change of X coordinate	Change of Y coordinate
Start	12	−(X+1)	Y−YMIN+1
Corner	13	−(X+1)	−(Y−YMIN+1)
Curve	14	X+1	Y−YMIN+1
Tangent	15	X+1	−(Y−YMIN+1)

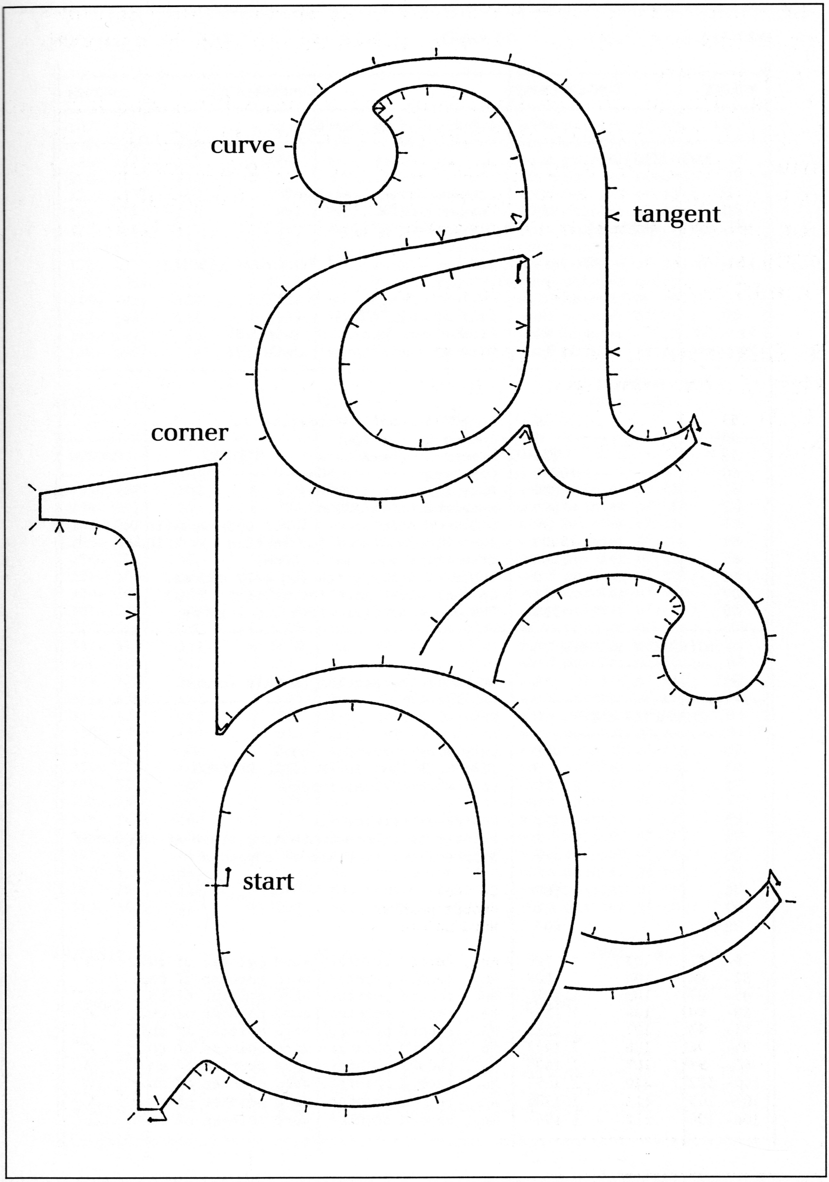
The X and Y coordinates are stored in the smallest possible units. As a rule this is 1/100 mm (see also measurement unit in appendix G, character record).

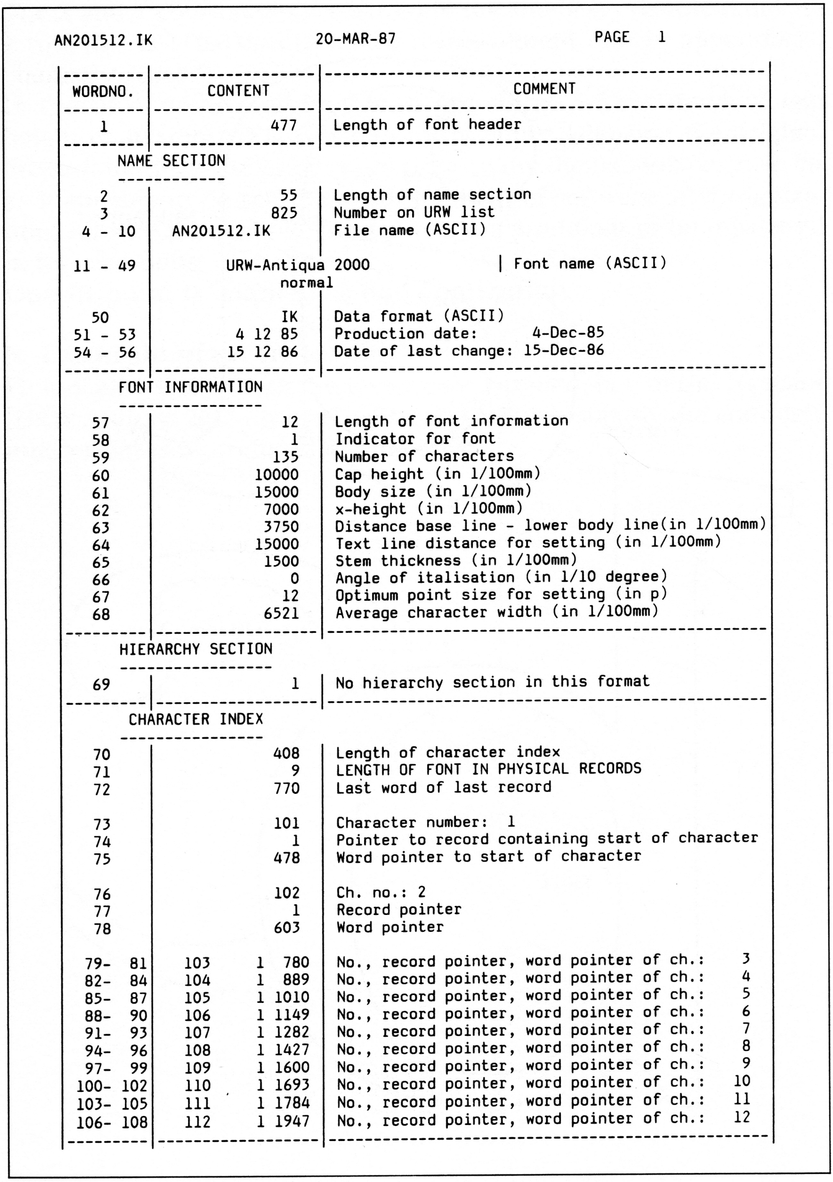
In the URW archive all type fonts are stored with a standard cap height of 100 mm. This is achieved by either adjusting the original artwork to this value using repro prior to the digitization or, in so far as it appears to be sensible, with the help of software after digitization. All size details in IK format headers are taken to be measured in the said units.

One IK point is counted as one digitization.

3. Example of an IK format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", with marks. Subsequently the complete font format is reproduced as a data list.


curve
tangent
corner
start



```
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|---------|------------------|----------------------------------------------|
| WORDNO. |     CONTENT      |                   COMMENT                    |
|---------|------------------|----------------------------------------------|
|    1    |              477 | Length of font header                        |
|---------|------------------|----------------------------------------------|
       NAME SECTION
       ------------
     2    |               55 | Length of name section
     3    |              825 | Number on URW list
   4 - 10 |   AN201512.IK    | File name (ASCII)
          |                  |
  11 - 49          URW-Antiqua 2000            | Font name (ASCII)
                         normal
          |                  |
    50    |               IK | Data format (ASCII)
  51 - 53 |          4 12 85 | Production date:       4-Dec-85
  54 - 56 |         15 12 86 | Date of last change: 15-Dec-86
 ---------|------------------|----------------------------------------------
       FONT INFORMATION
       ----------------
    57    |               12 | Length of font information
    58    |                1 | Indicator for font
    59    |              135 | Number of characters
    60    |            10000 | Cap height (in 1/100mm)
    61    |            15000 | Body size (in 1/100mm)
    62    |             7000 | x-height (in 1/100mm)
    63    |             3750 | Distance base line - lower body line(in 1/100mm)
    64    |            15000 | Text line distance for setting (in 1/100mm)
    65    |             1500 | Stem thickness (in 1/100mm)
    66    |                0 | Angle of italisation (in 1/10 degree)
    67    |               12 | Optimum point size for setting (in p)
    68    |             6521 | Average character width (in 1/100mm)
 ---------|------------------|----------------------------------------------
       HIERARCHY SECTION
       -----------------
    69    |                1 | No hierarchy section in this format
 ---------|------------------|----------------------------------------------
         CHARACTER INDEX
         ---------------
    70    |              408 | Length of character index
    71    |                9 | LENGTH OF FONT IN PHYSICAL RECORDS
    72    |              770 | Last word of last record
          |                  |
    73    |              101 | Character number:  1
    74    |                1 | Pointer to record containing start of character
    75    |              478 | Word pointer to start of character
          |                  |
    76    |              102 | Ch. no.: 2
    77    |                1 | Record pointer
    78    |              603 | Word pointer
          |                  |
   79-  81|    103     1  780| No., record pointer, word pointer of ch.:    3
   82-  84|    104     1  889| No., record pointer, word pointer of ch.:    4
   85-  87|    105     1 1010| No., record pointer, word pointer of ch.:    5
   88-  90|    106     1 1149| No., record pointer, word pointer of ch.:    6
   91-  93|    107     1 1282| No., record pointer, word pointer of ch.:    7
   94-  96|    108     1 1427| No., record pointer, word pointer of ch.:    8
   97-  99|    109     1 1600| No., record pointer, word pointer of ch.:    9
  100- 102|    110     1 1693| No., record pointer, word pointer of ch.:   10
  103- 105|    111     1 1784| No., record pointer, word pointer of ch.:   11
  106- 108|    112     1 1947| No., record pointer, word pointer of ch.:   12
 ---------|------------------|----------------------------------------------
```

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|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
| 109- 111|  113      1 2046 | No., record pointer, word pointer of ch.:   13 |
| 112- 114|  114      2  143 | No., record pointer, word pointer of ch.:   14 |
| 115- 117|  115      2  266 | No., record pointer, word pointer of ch.:   15 |
| 118- 120|  116      2  367 | No., record pointer, word pointer of ch.:   16 |
| 121- 123|  117      2  506 | No., record pointer, word pointer of ch.:   17 |
| 124- 126|  118      2  647 | No., record pointer, word pointer of ch.:   18 |
| 127- 129|  119      2  840 | No., record pointer, word pointer of ch.:   19 |
| 130- 132|  120      2  983 | No., record pointer, word pointer of ch.:   20 |
| 133- 135|  121      2 1084 | No., record pointer, word pointer of ch.:   21 |
| 136- 138|  122      2 1221 | No., record pointer, word pointer of ch.:   22 |
| 139- 141|  123      2 1316 | No., record pointer, word pointer of ch.:   23 |
| 142- 144|  124      2 1439 | No., record pointer, word pointer of ch.:   24 |
| 145- 147|  125      2 1612 | No., record pointer, word pointer of ch.:   25 |
| 148- 150|  126      2 1741 | No., record pointer, word pointer of ch.:   26 |

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|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
| 286- 288|  502      6  659 | No., record pointer, word pointer of ch.:   72 |
| 289- 291|  503      6  794 | No., record pointer, word pointer of ch.:   73 |
| 292- 294|  504      6  927 | No., record pointer, word pointer of ch.:   74 |
| 295- 297|  505      6 1004 | No., record pointer, word pointer of ch.:   75 |
| 298- 300|  506      6 1155 | No., record pointer, word pointer of ch.:   76 |
| 301- 303|  507      6 1308 | No., record pointer, word pointer of ch.:   77 |
| 304- 306|  508      6 1397 | No., record pointer, word pointer of ch.:   78 |
| 307- 309|  509      6 1574 | No., record pointer, word pointer of ch.:   79 |
| 310- 312|  510      6 1729 | No., record pointer, word pointer of ch.:   80 |
| 313- 315|  511      6 1830 | No., record pointer, word pointer of ch.:   81 |
| 316- 318|  512      7   27 | No., record pointer, word pointer of ch.:   82 |
| 319- 321|  513      7  266 | No., record pointer, word pointer of ch.:   83 |
| 322- 324|  601      7  425 | No., record pointer, word pointer of ch.:   84 |
| 325- 327|  602      7  462 | No., record pointer, word pointer of ch.:   85 |
| 328- 330|  603      7  515 | No., record pointer, word pointer of ch.:   86 |
| 331- 333|  604      7  552 | No., record pointer, word pointer of ch.:   87 |
| 334- 336|  605      7  589 | No., record pointer, word pointer of ch.:   88 |
| 337- 339|  606      7  626 | No., record pointer, word pointer of ch.:   89 |
| 340- 342|  607      7  695 | No., record pointer, word pointer of ch.:   90 |
| 343- 345|  608      7  770 | No., record pointer, word pointer of ch.:   91 |
| 346- 348|  609      7  861 | No., record pointer, word pointer of ch.:   92 |
| 349- 351|  610      7  936 | No., record pointer, word pointer of ch.:   93 |
| 352- 354|  611      7 1011 | No., record pointer, word pointer of ch.:   94 |
| 355- 357|  612      7 1140 | No., record pointer, word pointer of ch.:   95 |
| 358- 360|  613      7 1269 | No., record pointer, word pointer of ch.:   96 |

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|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
| 463- 465|  754      9  462 | No., record pointer, word pointer of ch.:  131 |
| 466- 468|  755      9  511 | No., record pointer, word pointer of ch.:  132 |
| 469- 471|  756      9  560 | No., record pointer, word pointer of ch.:  133 |
| 472- 474|  759      9  601 | No., record pointer, word pointer of ch.:  134 |
| 475- 477|  761      9  692 | No., record pointer, word pointer of ch.:  135 |
|         |                  |                                                |
|---------|------------------|-----------------------------------------------|
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|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
|    1    |                 0| Records      length of character              |
|    2    |               185| Words                                         |
|---------|------------------|-----------------------------------------------|
|     NAME SECTION                                                           |
|     ------------                                                           |
|    3    |                 3| Length of name section                        |
|    4    |               301| Character number                              |
|    5    |                 0| Number of following part                      |
|---------|------------------|-----------------------------------------------|
|     SETTING INFORMATION                                                    |
|     -------------------                                                    |
|    6    |                12| Length of setting information                 |
|    7    |                 1| Character type = letter                       |
|    8    |                76| Number of digitizations                       |
|    9    |              7710| Total set width (T=L+W+R)                     |
|   10    |               550| Left side bearing (L)                         |
|   11    |              7280| Width (W)                                     |
|   12    |              -120| Right side bearing (R)                        |
|   13    |                 0| X-minimum                                     |
|   14    |              7280| X-maximum                                     |
|   15    |              -150| Y-minimum                                     |
|   16    |              7150| Y-maximum                                     |
|   17    |                 1| Unit is 1/100mm                               |
|---------|------------------|-----------------------------------------------|
|     CONTOUR INDEX                                                          |
|     -------------                                                          |
|   18    |                 0| Records     length of contour index           |
|   19    |                14| Words                                         |
|                                                                            |
|   20    |                 0| Record pointer for   1. contour:      0       |
|   21    |                 3| Word pointer                     :    34      |
|   22    |                -1| Sense of rotation of contour = clockwise      |
|   23    |                 0| Nesting: outer  1. order                      |
|   24    |                 0| Colour inside: transparent                    |
|   25    |                60| Number of digitizations                       |
|                                                                            |
|   26    |                 0| Record pointer for   2. contour:      0       |
|   27    |               123| Word pointer                     :   154      |
|   28    |                -1| Sense of rotation of contour = clockwise      |
|   29    |                 1| Nesting: inner  1. order                      |
|   30    |                 0| Colour inside: transparent                    |
|   31    |                16| Number of digitizations                       |
|                                                                            |
|---------|------------------|-----------------------------------------------|
|     IMAGE INFORMATION                                                      |
|     -----------------                                                      |
|   32    |                 0| Records     length of image information       |
|   33    |               154| Words                                         |
|                                                                            |
|  34- 35 |  -7184   1204    | 12   7183   1053 (K,X,Y)       1.DIG; typ: STRP |
|  36- 37 |  -7281   -921    | 13   7280    770 (K,X,Y)       2.DIG; typ: -EP- |
|  38- 39 |   6915    575    | 14   6914    424 (K,X,Y)       3.DIG; typ: .C.. |
|  40- 41 |   6343    234    | 14   6342     83 (K,X,Y)       4.DIG; typ: .C.. |
|  42- 43 |   5714     51    | 14   5713   -100 (K,X,Y)       5.DIG; typ: .C.. |
|  44- 45 |   5215    147    | 14   5214     -4 (K,X,Y)       6.DIG; typ: .C.. |
|  46- 47 |   4795    493    | 14   4794    342 (K,X,Y)       7.DIG; typ: .C.. |
|  48- 49 |   4583    952    | 14   4582    801 (K,X,Y)       8.DIG; typ: .C.. |
|  50- 51 |  -4513  -1204    | 13   4512   1053 (K,X,Y)       9.DIG; typ: -EP- |
|---------|------------------|-----------------------------------------------|
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|---------|------------------|---------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT
|---------|------------------|---------------------------------------------------|
|  52-  53|  -4428   -1204   | 13   4427   1053 (K,X,Y)   10.DIG; typ: -EP-       |
|  54-  55|   4075     842   | 14   4074    691 (K,X,Y)   11.DIG; typ: .C..       |
|  56-  57|   3491     406   | 14   3490    255 (K,X,Y)   12.DIG; typ: .C..       |
|  58-  59|   2724      88   | 14   2723    -63 (K,X,Y)   13.DIG; typ: .C..       |
|  60-  61|   2055       1   | 14   2054   -150 (K,X,Y)   14.DIG; typ: .C..       |
|  62-  63|    991     239   | 14    990     88 (K,X,Y)   15.DIG; typ: .C..       |
|  64-  65|    196    1068   | 14    195    917 (K,X,Y)   16.DIG; typ: .C..       |
|  66-  67|      1    2075   | 14      0   1924 (K,X,Y)   17.DIG; typ: .C..       |
|  68-  69|    138    2820   | 14    137   2669 (K,X,Y)   18.DIG; typ: .C..       |
|  70-  71|    542    3417   | 14    541   3266 (K,X,Y)   19.DIG; typ: .C..       |
|  72-  73|   1530    3940   | 14   1529   3789 (K,X,Y)   20.DIG; typ: .C..       |
|  74-  75|   2523    4150   | 14   2522   3999 (K,X,Y)   21.DIG; typ: .C..       |
|  76-  77|   3094   -4240   | 15   3093   4089 (K,X,Y)   22.DIG; typ: >TP<       |
|  78-  79|  -4370   -4469   | 13   4369   4318 (K,X,Y)   23.DIG; typ: -EP-       |
|  80-  81|  -4491   -4635   | 13   4490   4484 (K,X,Y)   24.DIG; typ: -EP-       |
|  82-  83|   4479    5086   | 14   4478   4935 (K,X,Y)   25.DIG; typ: .C..       |
|  84-  85|   4385    5665   | 14   4384   5514 (K,X,Y)   26.DIG; typ: .C..       |
|  86-  87|   4019    6424   | 14   4018   6273 (K,X,Y)   27.DIG; typ: .C..       |
|  88-  89|   3442    6770   | 14   3441   6619 (K,X,Y)   28.DIG; typ: .C..       |
|  90-  91|   2851    6849   | 14   2850   6698 (K,X,Y)   29.DIG; typ: .C..       |
|  92-  93|   2421    6780   | 14   2420   6629 (K,X,Y)   30.DIG; typ: .C..       |
|  94-  95|   2185    6685   | 14   2184   6534 (K,X,Y)   31.DIG; typ: .C..       |
|  96-  97|   2050    6595   | 14   2049   6444 (K,X,Y)   32.DIG; typ: .C..       |
|  98-  99|   1962    6476   | 14   1961   6325 (K,X,Y)   33.DIG; typ: .C..       |
| 100- 101|   2025    6364   | 14   2024   6213 (K,X,Y)   34.DIG; typ: .C..       |
| 102- 103|   2155    6237   | 14   2154   6086 (K,X,Y)   35.DIG; typ: .C..       |
| 104- 105|   2302    6011   | 14   2301   5860 (K,X,Y)   36.DIG; typ: .C..       |
| 106- 107|   2353    5734   | 14   2352   5583 (K,X,Y)   37.DIG; typ: .C..       |
| 108- 109|   2256    5343   | 14   2255   5192 (K,X,Y)   38.DIG; typ: .C..       |
| 110- 111|   1931    5010   | 14   1930   4859 (K,X,Y)   39.DIG; typ: .C..       |
| 112- 113|   1469    4908   | 14   1468   4757 (K,X,Y)   40.DIG; typ: .C..       |
| 114- 115|   1123    4979   | 14   1122   4828 (K,X,Y)   41.DIG; typ: .C..       |
| 116- 117|    735    5384   | 14    734   5233 (K,X,Y)   42.DIG; typ: .C..       |
| 118- 119|    654    5843   | 14    653   5692 (K,X,Y)   43.DIG; typ: .C..       |
| 120- 121|    748    6240   | 14    747   6089 (K,X,Y)   44.DIG; typ: .C..       |
| 122- 123|   1142    6761   | 14   1141   6610 (K,X,Y)   45.DIG; typ: .C..       |
| 124- 125|   2001    7168   | 14   2000   7017 (K,X,Y)   46.DIG; typ: .C..       |
| 126- 127|   3009    7301   | 14   3008   7150 (K,X,Y)   47.DIG; typ: .C..       |
| 128- 129|   4198    7203   | 14   4197   7052 (K,X,Y)   48.DIG; typ: .C..       |
| 130- 131|   5057    6815   | 14   5056   6664 (K,X,Y)   49.DIG; typ: .C..       |
| 132- 133|   5641    6012   | 14   5640   5861 (K,X,Y)   50.DIG; typ: .C..       |
| 134- 135|   5813    5130   | 14   5812   4979 (K,X,Y)   51.DIG; typ: .C..       |
| 136- 137|   5813   -4657   | 15   5812   4506 (K,X,Y)   52.DIG; typ: >TP<       |
| 138- 139|   5813   -2422   | 15   5812   2271 (K,X,Y)   53.DIG; typ: >TP<       |
| 140- 141|   5820    2043   | 14   5819   1892 (K,X,Y)   54.DIG; typ: .C..       |
| 142- 143|   5869    1528   | 14   5868   1377 (K,X,Y)   55.DIG; typ: .C..       |
| 144- 145|   6135    1070   | 14   6134    919 (K,X,Y)   56.DIG; typ: .C..       |
| 146- 147|   6482     959   | 14   6481    808 (K,X,Y)   57.DIG; typ: .C..       |
| 148- 149|   6799    1011   | 14   6798    860 (K,X,Y)   58.DIG; typ: .C..       |
| 150- 151|   7061    1121   | 14   7060    970 (K,X,Y)   59.DIG; typ: .C..       |
| 152- 153|  -7184   -1204   | 13   7183   1053 (K,X,Y)   60.DIG; typ: -EP-       |
| 154- 155|  -4513    3950   | 12   4512   3799 (K,X,Y)   61.DIG; typ: STRP       |
| 156- 157|   4513   -2866   | 15   4512   2715 (K,X,Y)   62.DIG; typ: >TP<       |
| 158- 159|   4488    2434   | 14   4487   2283 (K,X,Y)   63.DIG; typ: .C..       |
| 160- 161|   4351    1832   | 14   4350   1681 (K,X,Y)   64.DIG; typ: .C..       |
| 162- 163|   4056    1388   | 14   4055   1237 (K,X,Y)   65.DIG; typ: .C..       |
| 164- 165|   3462     974   | 14   3461    823 (K,X,Y)   66.DIG; typ: .C..       |
| 166- 167|   2718     822   | 14   2717    671 (K,X,Y)   67.DIG; typ: .C..       |
| 168- 169|   1990    1023   | 14   1989    872 (K,X,Y)   68.DIG; typ: .C..       |
|---------|------------------|---------------------------------------------------|
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|---------|-----------------|---------------------------------------------|
| WORDNO. |     CONTENT     |                   COMMENT                   |
|---------|-----------------|---------------------------------------------|
| 170- 171|   1521    1552  | 14   1520   1401 (K,X,Y)    69.DIG; typ: .C..
| 172- 173|   1390    2238  | 14   1389   2087 (K,X,Y)    70.DIG; typ: .C..
| 174- 175|   1555    2933  | 14   1554   2782 (K,X,Y)    71.DIG; typ: .C..
| 176- 177|   2076    3437  | 14   2075   3286 (K,X,Y)    72.DIG; typ: .C..
| 178- 179|   2751    3675  | 14   2750   3524 (K,X,Y)    73.DIG; typ: .C..
| 180- 181|   3226    3790  | 14   3225   3639 (K,X,Y)    74.DIG; typ: .C..
| 182- 183|  -4420   -4019  | 13   4419   3868 (K,X,Y)    75.DIG; typ: -EP-
| 184- 185|  -4513   -3950  | 13   4512   3799 (K,X,Y)    76.DIG; typ: -EP-
|         |                 |                                             |
|---------|-----------------|---------------------------------------------|
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|---------|-----------------|---------------------------------------------|
| WORDNO. |     CONTENT     |                   COMMENT                   |
|---------|-----------------|---------------------------------------------|
|    1    |               0 | Records      length of character
|    2    |             135 | Words
|---------|-----------------|---------------------------------------------|
      NAME SECTION
      ------------
     3    |               3 | Length of name section
     4    |             302 | Character number
     5    |               0 | Number of following part
 ---------|-----------------|---------------------------------------------
      SETTING INFORMATION
      -------------------
     6    |              12 | Length of setting information
     7    |               1 | Character type = letter
     8    |              51 | Number of digitizations
     9    |            9637 | Total set width (T=L+W+R)
    10    |               0 | Left side bearing (L)
    11    |            8887 | Width (W)
    12    |             750 | Right side bearing (R)
    13    |               0 | X-minimum
    14    |            8887 | X-maximum
    15    |            -200 | Y-minimum
    16    |           10500 | Y-maximum
    17    |               1 | Unit is 1/100mm
 ---------|-----------------|---------------------------------------------
      CONTOUR INDEX
      -------------
    18    |               0 | Records     length of contour index
    19    |              14 | Words
          |                 |
    20    |               0 | Record pointer for   1. contour:     0
    21    |               3 | Word pointer                   :    34
    22    |              -1 | Sense of rotation of contour = clockwise
    23    |               0 | Nesting: outer  1. order
    24    |               0 | Colour inside: transparent
    25    |              34 | Number of digitizations
          |                 |
    26    |               0 | Record pointer for   2. contour:     0
    27    |              71 | Word pointer                   :   102
    28    |              -1 | Sense of rotation of contour = clockwise
    29    |               1 | Nesting: inner  1. order
    30    |               0 | Colour inside: transparent
    31    |              17 | Number of digitizations
|         |                 |                                             |
|---------|-----------------|---------------------------------------------|
|       IMAGE INFORMATION
|       -----------------
   32    |                 0 | Records     length of image information
   33    |               104 | Words
         |                   |
  34-  35|  -2005         1  | 12     2004   -200 (K,X,Y)      1.DIG; typ: STRP
  36-  37|  -1629        -1  | 13     1628   -200 (K,X,Y)      2.DIG; typ: -EP-
  38-  39|   1629     -8197  | 15     1628   7996 (K,X,Y)      3.DIG; typ: >TP<
  40-  41|   1627      8536  | 14     1626   8335 (K,X,Y)      4.DIG; typ: .C..
  42-  43|   1571      9067  | 14     1570   8866 (K,X,Y)      5.DIG; typ: .C..
  44-  45|   1363      9479  | 14     1362   9278 (K,X,Y)      6.DIG; typ: .C..
  46-  47|    954      9679  | 14      953   9478 (K,X,Y)      7.DIG; typ: .C..
  48-  49|    326     -9762  | 15      325   9561 (K,X,Y)      8.DIG; typ: >TP<
  50-  51|     -1     -9771  | 13        0   9570 (K,X,Y)      9.DIG; typ: -EP-
|---------|------------------|---------------------------------------------------|

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|---------|------------------|---------------------------------------------------|
| WORDNO. |      CONTENT     |                     COMMENT
|---------|------------------|---------------------------------------------------|
  52-  53|     -1    -10201  | 13        0  10000 (K,X,Y)     10.DIG; typ: -EP-
  54-  55|  -2929    -10701  | 13     2928  10500 (K,X,Y)     11.DIG; typ: -EP-
  56-  57|  -2929     -6217  | 13     2928   6016 (K,X,Y)     12.DIG; typ: -EP-
  58-  59|  -3023     -6217  | 13     3022   6016 (K,X,Y)     13.DIG; typ: -EP-
  60-  61|   3211      6467  | 14     3210   6266 (K,X,Y)     14.DIG; typ: .C..
  62-  63|   3975      7021  | 14     3974   6820 (K,X,Y)     15.DIG; typ: .C..
  64-  65|   4883      7304  | 14     4882   7103 (K,X,Y)     16.DIG; typ: .C..
  66-  67|   5680      7351  | 14     5679   7150 (K,X,Y)     17.DIG; typ: .C..
  68-  69|   6775      7182  | 14     6774   6981 (K,X,Y)     18.DIG; typ: .C..
  70-  71|   7811      6619  | 14     7810   6418 (K,X,Y)     19.DIG; typ: .C..
  72-  73|   8609      5518  | 14     8608   5317 (K,X,Y)     20.DIG; typ: .C..
  74-  75|   8888      4212  | 14     8887   4011 (K,X,Y)     21.DIG; typ: .C..
  76-  77|   8673      2466  | 14     8672   2265 (K,X,Y)     22.DIG; typ: .C..
  78-  79|   7809       987  | 14     7808    786 (K,X,Y)     23.DIG; typ: .C..
  80-  81|   6539       257  | 14     6538     56 (K,X,Y)     24.DIG; typ: .C..
  82-  83|   5068        51  | 14     5067   -150 (K,X,Y)     25.DIG; typ: .C..
  84-  85|   4418       114  | 14     4417    -87 (K,X,Y)     26.DIG; typ: .C..
  86-  87|   3719       299  | 14     3718     98 (K,X,Y)     27.DIG; typ: .C..
  88-  89|   3161       573  | 14     3160    372 (K,X,Y)     28.DIG; typ: .C..
  90-  91|   2930       728  | 14     2929    527 (K,X,Y)     29.DIG; typ: .C..
  92-  93|   2754       800  | 14     2753    599 (K,X,Y)     30.DIG; typ: .C..
  94-  95|   2545       664  | 14     2544    463 (K,X,Y)     31.DIG; typ: .C..
  96-  97|   2354       444  | 14     2353    243 (K,X,Y)     32.DIG; typ: .C..
  98-  99|   2153       192  | 14     2152     -9 (K,X,Y)     33.DIG; typ: .C..
 100- 101|  -2005        -1  | 13     2004   -200 (K,X,Y)     34.DIG; typ: -EP-
 102- 103|  -2909      3706  | 12     2908   3505 (K,X,Y)     35.DIG; typ: STRP
 104- 105|   2995      4933  | 14     2994   4732 (K,X,Y)     36.DIG; typ: .C..
 106- 107|   3404      5949  | 14     3403   5748 (K,X,Y)     37.DIG; typ: .C..
 108- 109|   4197      6571  | 14     4196   6370 (K,X,Y)     38.DIG; typ: .C..
 110- 111|   5182      6769  | 14     5181   6568 (K,X,Y)     39.DIG; typ: .C..
 112- 113|   6000      6596  | 14     5999   6395 (K,X,Y)     40.DIG; typ: .C..
 114- 115|   6732      6071  | 14     6731   5870 (K,X,Y)     41.DIG; typ: .C..
 116- 117|   7202      5096  | 14     7201   4895 (K,X,Y)     42.DIG; typ: .C..
 118- 119|   7347      3907  | 14     7346   3706 (K,X,Y)     43.DIG; typ: .C..
 120- 121|   7263      2627  | 14     7262   2426 (K,X,Y)     44.DIG; typ: .C..
 122- 123|   6656      1291  | 14     6655   1090 (K,X,Y)     45.DIG; typ: .C..
 124- 125|   6026       803  | 14     6025    602 (K,X,Y)     46.DIG; typ: .C..
 126- 127|   5076       574  | 14     5075    373 (K,X,Y)     47.DIG; typ: .C..
 128- 129|   4179       795  | 14     4178    594 (K,X,Y)     48.DIG; typ: .C..
 130- 131|   3468      1359  | 14     3467   1158 (K,X,Y)     49.DIG; typ: .C..
 132- 133|   2973      2581  | 14     2972   2380 (K,X,Y)     50.DIG; typ: .C..
 134- 135|   2909      3706  | 14     2908   3505 (K,X,Y)     51.DIG; typ: .C..
         |                   |
|---------|------------------|---------------------------------------------------|
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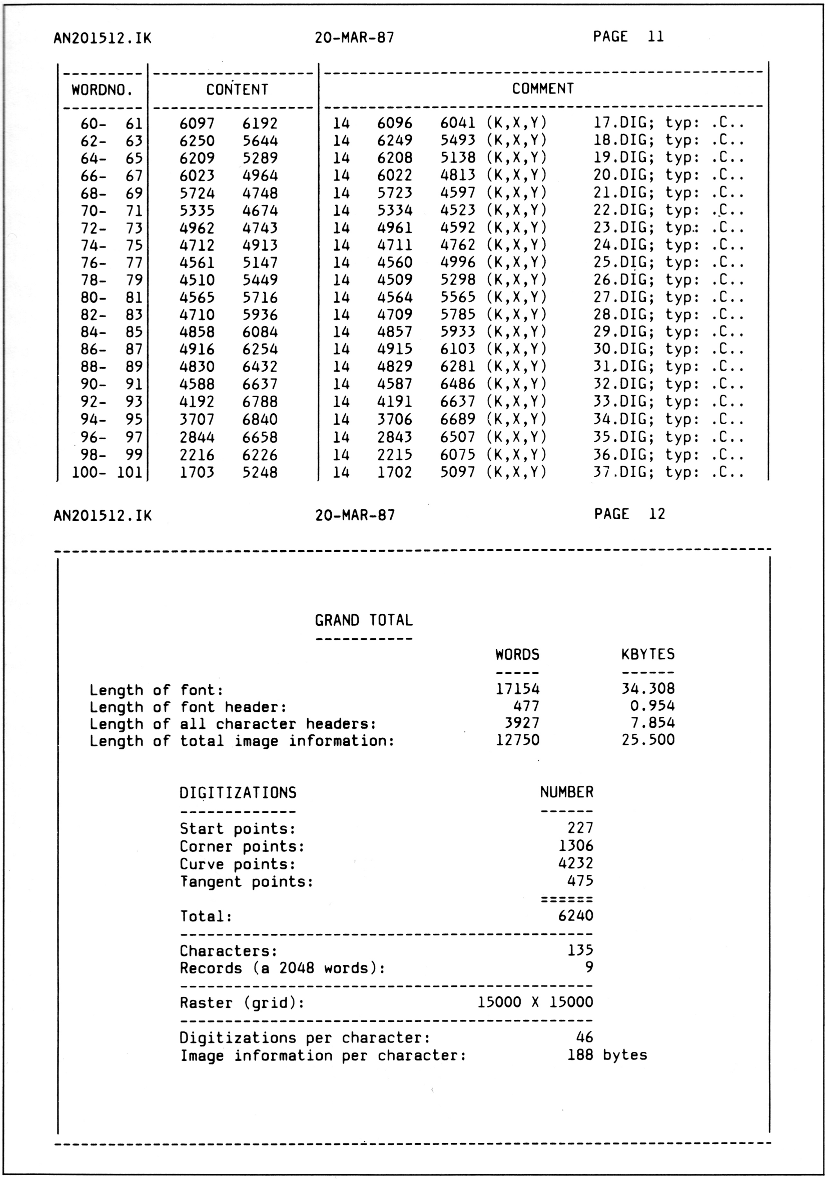
|---------|------------------|--------------------------------------------------|
| WORDNO. |      CONTENT     |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|    1    |                 0| Records      length of character                 |
|    2    |               119| Words                                            |
|---------|------------------|--------------------------------------------------|
|     NAME SECTION                                                              |
|     ------------                                                              |
|    3    |                 3| Length of name section                           |
|    4    |               303| Character number                                 |
|    5    |                 0| Number of following part                         |
|---------|------------------|--------------------------------------------------|
|     SETTING INFORMATION                                                       |
|     -------------------                                                       |
|    6    |                12| Length of setting information                    |
|    7    |                 1| Character type = letter                          |
|    8    |                46| Number of digitizations                          |
|    9    |              7407| Total set width (T=L+W+R)                        |
|   10    |               749| Left side bearing (L)                            |
|   11    |              6249| Width (W)                                        |
|   12    |               409| Right side bearing (R)                           |
|   13    |                 0| X-minimum                                        |
|   14    |              6249| X-maximum                                        |
|   15    |              -150| Y-minimum                                        |
|   16    |              7150| Y-maximum                                        |
|   17    |                 1| Unit is 1/100mm                                  |
|---------|------------------|--------------------------------------------------|
|     CONTOUR INDEX                                                             |
|     -------------                                                             |
|   18    |                 0| Records     length of contour index              |
|   19    |                 8| Words                                            |
|         |                  |                                                  |
|   20    |                 0| Record pointer for   1. ccntour:      0          |
|   21    |                 3| Word pointer                    :    28          |
|   22    |                -1| Sense of rotation of contour = clockwise         |
|   23    |                 0| Nesting: outer  1. order                         |
|   24    |                 0| Colour inside: transparent                       |
|   25    |                46| Number of digitizations                          |
|         |                  |                                                  |
|---------|------------------|--------------------------------------------------|
|     IMAGE INFORMATION                                                         |
|     -----------------                                                         |
|   26    |                 0| Records     length of image information          |
|   27    |                94| Words                                            |
|         |                  |                                                  |
|  28- 29 |  -6003   1593    | 12   6002   1442 (K,X,Y)       1.DIG; typ: STRP  |
|  30- 31 |  -6173  -1263    | 13   6172   1112 (K,X,Y)       2.DIG; typ: -EP-  |
|  32- 33 |   5848    940    | 14   5847    789 (K,X,Y)       3.DIG; typ: .C..  |
|  34- 35 |   5145    455    | 14   5144    304 (K,X,Y)       4.DIG; typ: .C..  |
|  36- 37 |   4258    122    | 14   4257    -29 (K,X,Y)       5.DIG; typ: .C..  |
|  38- 39 |   3283      1    | 14   3282   -150 (K,X,Y)       6.DIG; typ: .C..  |
|  40- 41 |   2117    206    | 14   2116     55 (K,X,Y)       7.DIG; typ: .C..  |
|  42- 43 |   1081    854    | 14   1080    703 (K,X,Y)       8.DIG; typ: .C..  |
|  44- 45 |    281   2101    | 14    280   1950 (K,X,Y)       9.DIG; typ: .C..  |
|  46- 47 |      1   3691    | 14      0   3540 (K,X,Y)      10.DIG; typ: .C..  |
|  48- 49 |    245   5183    | 14    244   5032 (K,X,Y)      11.DIG; typ: .C..  |
|  50- 51 |    862   6244    | 14    861   6093 (K,X,Y)      12.DIG; typ: .C..  |
|  52- 53 |   1982   7030    | 14   1981   6879 (K,X,Y)      13.DIG; typ: .C..  |
|  54- 55 |   3397   7301    | 14   3396   7150 (K,X,Y)      14.DIG; typ: .C..  |
|  56- 57 |   4589   7172    | 14   4588   7021 (K,X,Y)      15.DIG; typ: .C..  |
|  58- 59 |   5541   6763    | 14   5540   6612 (K,X,Y)      16.DIG; typ: .C..  |
|---------|------------------|--------------------------------------------------|
```



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 ---------  ----------------  ---------------------------------------------
  WORDNO.        CONTENT                          COMMENT
 ---------  ----------------  ---------------------------------------------
    60-  61   6097    6192      14    6096    6041 (K,X,Y)      17.DIG; typ: .C..
    62-  63   6250    5644      14    6249    5493 (K,X,Y)      18.DIG; typ: .C..
    64-  65   6209    5289      14    6208    5138 (K,X,Y)      19.DIG; typ: .C..
    66-  67   6023    4964      14    6022    4813 (K,X,Y)      20.DIG; typ: .C..
    68-  69   5724    4748      14    5723    4597 (K,X,Y)      21.DIG; typ: .C..
    70-  71   5335    4674      14    5334    4523 (K,X,Y)      22.DIG; typ: .C..
    72-  73   4962    4743      14    4961    4592 (K,X,Y)      23.DIG; typ: .C..
    74-  75   4712    4913      14    4711    4762 (K,X,Y)      24.DIG; typ: .C..
    76-  77   4561    5147      14    4560    4996 (K,X,Y)      25.DIG; typ: .C..
    78-  79   4510    5449      14    4509    5298 (K,X,Y)      26.DIG; typ: .C..
    80-  81   4565    5716      14    4564    5565 (K,X,Y)      27.DIG; typ: .C..
    82-  83   4710    5936      14    4709    5785 (K,X,Y)      28.DIG; typ: .C..
    84-  85   4858    6084      14    4857    5933 (K,X,Y)      29.DIG; typ: .C..
    86-  87   4916    6254      14    4915    6103 (K,X,Y)      30.DIG; typ: .C..
    88-  89   4830    6432      14    4829    6281 (K,X,Y)      31.DIG; typ: .C..
    90-  91   4588    6637      14    4587    6486 (K,X,Y)      32.DIG; typ: .C..
    92-  93   4192    6788      14    4191    6637 (K,X,Y)      33.DIG; typ: .C..
    94-  95   3707    6840      14    3706    6689 (K,X,Y)      34.DIG; typ: .C..
    96-  97   2844    6658      14    2843    6507 (K,X,Y)      35.DIG; typ: .C..
    98-  99   2216    6226      14    2215    6075 (K,X,Y)      36.DIG; typ: .C..
   100- 101   1703    5248      14    1702    5097 (K,X,Y)      37.DIG; typ: .C..

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--------------------------------------------------------------------------------


                              GRAND TOTAL
                              -----------
                                                  WORDS           KBYTES
                                                  -----           ------
   Length of font:                                17154           34.308
   Length of font header:                           477            0.954
   Length of all character headers:                3927            7.854
   Length of total image information:             12750           25.500


            DIGITIZATIONS                              NUMBER
            -------------                              ------
            Start points:                                 227
            Corner points:                               1306
            Curve points:                                4232
            Tangent points:                               475
                                                       ======
            Total:                                       6240
            ------------------------------------------------
            Characters:                                   135
            Records (a 2048 words):                         9
            ------------------------------------------------
            Raster (grid):                      15000 X 15000
            ------------------------------------------------
            Digitizations per character:                   46
            Image information per character:              188 bytes


--------------------------------------------------------------------------------
```

Appendix J
Description of the DI format

1. Structure of a DI font

The structure of a DI font is as described in appendix G.

2. Description of the DI format

Because most graphic display terminals and NC machines (plotters) have hardware and software to decode and raster straight and circular line commands as given by the host computer, we have created a general, binary **display format.**

This is a closed contour format (as is the IK format) which describes the contours of any arbitrary flat surface as a sequence of straights and arcs.

With regard to typesetters using circular and straight line interpolation, and for drawing machines which can only address a certain grid resolution with line commands, this format may also be supplied with all positions of straights and arcs matching points within the corresponding equipment grid.

This display format describes a contour such that it contains the coordinates of the end points of all straights and arcs, and radii and direction of arc rotation in a binary form. Special command codes for the various codes of certain machine types (e.g. in ASCII) can be easily derived with the aid of a simple converter program (as a post processor). In a similar manner such a post processor needs to be programmed with only simple formulae from elementary geometry, in order to be able to generate other determinant arc parameters for these machine types from the data supplied (e.g. instead of end point and radius: angle interval, start angle and direction of tangent).

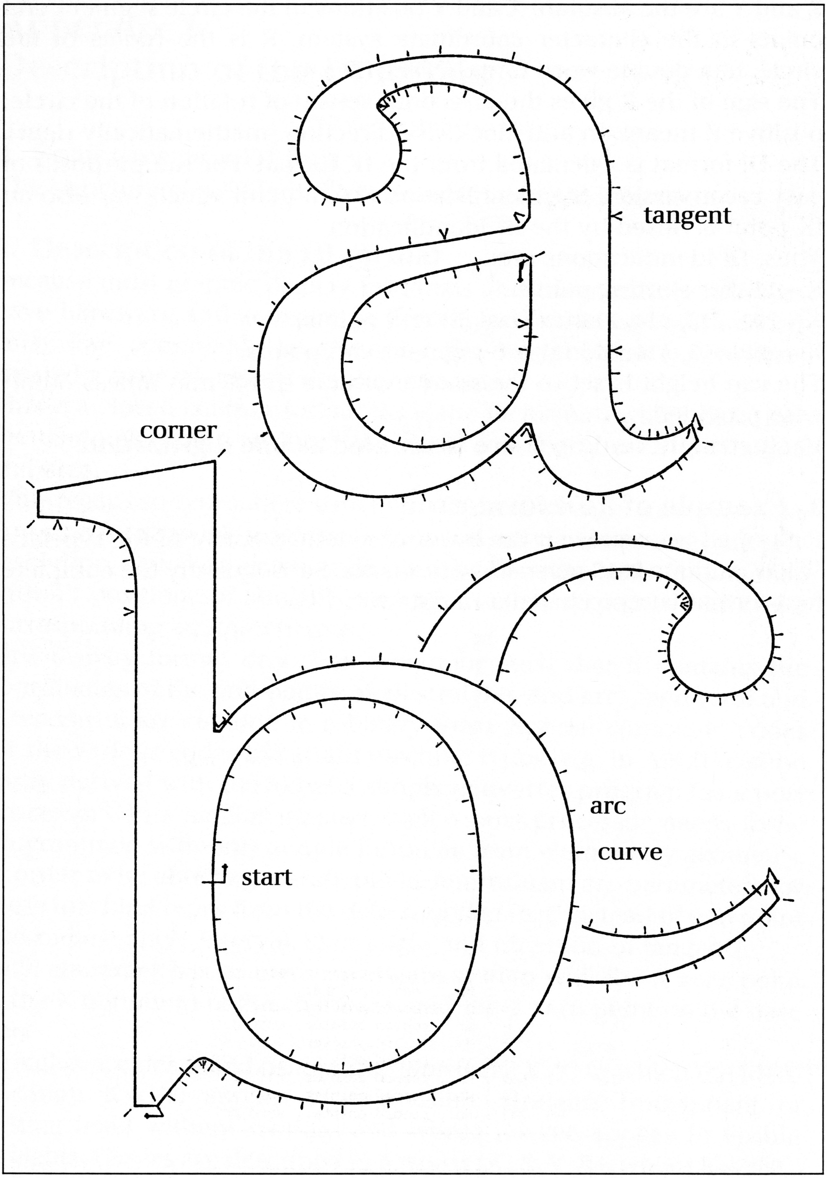
Each character has its own coordinate system with the X zero point at the X minimum of the character, and the Y zero point on the base line.

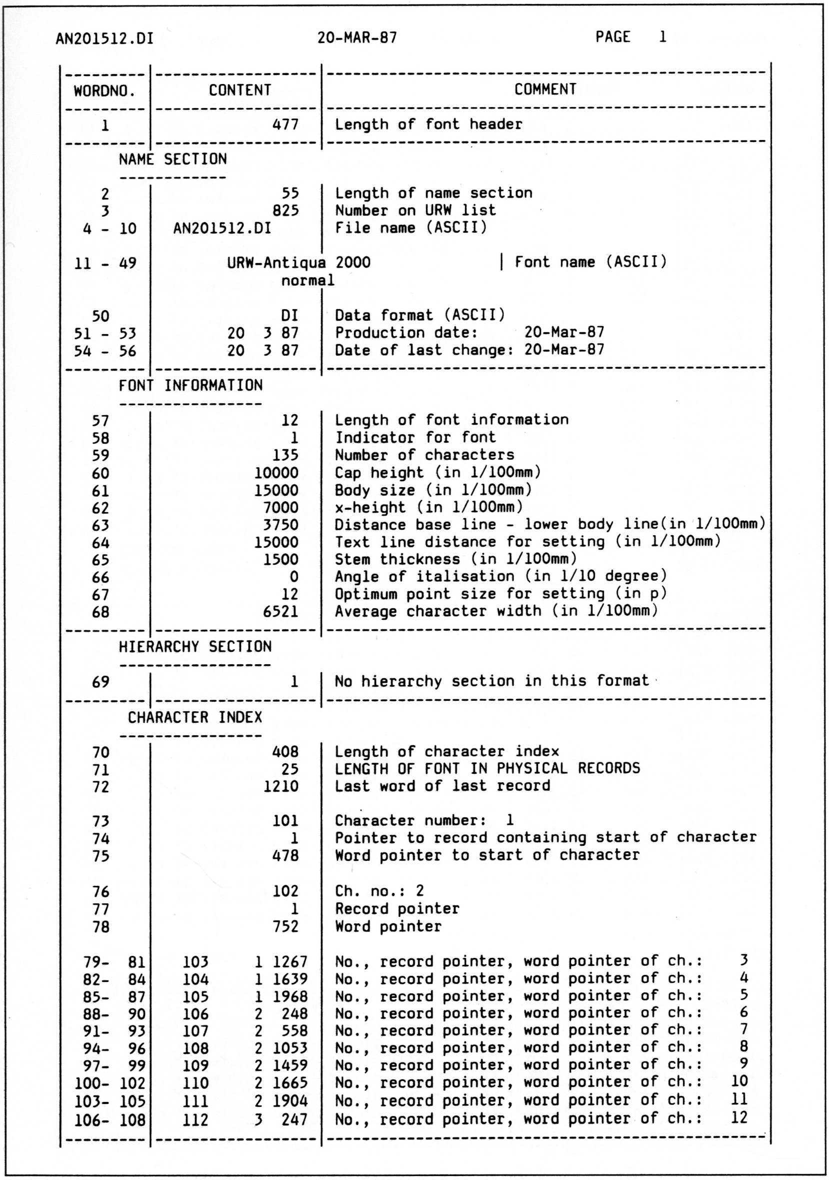
Straights are described using three words (K, X, Y) in which the identification K = 100 applies to non-visible straights (movement of writing head without writing) and where K = 200 applies to visible straights. Circles are described in 5 words (K, X, Y, R); where K = 300.

X and Y are the absolute X and Y positions of the circle segment end points in the character coordinate system. R is the radius of the circle, in a double word form (INTEGER × 4).
The sign of the R gives the direction (sense) of rotation of the circle: positive R means an anti-clockwise direction (mathematically right).
The DI format is calculated from the IK format. For the purposes of easy reconversion, the identification K of a point which was also an IK point is raised by the IK identification.
Thus, DI identifications are:
K = 112 for starting points,
K = 200, 213, 214, 215 for straight end points,
K = 300, 313, 314, 315 for arc segment end points.
The cap height is set to the standard value of 100 mm unless otherwise provided.
Each straight and each arc is counted as one digitization.

3. Example of a DI format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", with marks. Subsequently the complete font format is reproduced as a data list.


tangent
corner
arc
curve
start



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|---------|------------------|------------------------------------------------|
| WORDNO. |      CONTENT     |                    COMMENT                     |
|---------|------------------|------------------------------------------------|
|    1    |               477| Length of font header                          |
|---------|------------------|------------------------------------------------|
|     NAME SECTION                                                            |
|     ------------                                                            |
|    2    |                55| Length of name section                         |
|    3    |               825| Number on URW list                             |
|  4 - 10 |  AN201512.DI     | File name (ASCII)                              |
|         |                  |                                                |
| 11 - 49 |        URW-Antiqua 2000                | Font name (ASCII)        |
|         |              normal                                               |
|         |                  |                                                |
|   50    |                DI| Data format (ASCII)                            |
| 51 - 53 |          20  3 87| Production date:     20-Mar-87                 |
| 54 - 56 |          20  3 87| Date of last change: 20-Mar-87                 |
|---------|------------------|------------------------------------------------|
|     FONT INFORMATION                                                        |
|     ----------------                                                        |
|   57    |                12| Length of font information                     |
|   58    |                 1| Indicator for font                             |
|   59    |               135| Number of characters                           |
|   60    |             10000| Cap height (in 1/100mm)                        |
|   61    |             15000| Body size (in 1/100mm)                         |
|   62    |              7000| x-height (in 1/100mm)                          |
|   63    |              3750| Distance base line - lower body line(in 1/100mm)
|   64    |             15000| Text line distance for setting (in 1/100mm)    |
|   65    |              1500| Stem thickness (in 1/100mm)                    |
|   66    |                 0| Angle of italisation (in 1/10 degree)          |
|   67    |                12| Optimum point size for setting (in p)          |
|   68    |              6521| Average character width (in 1/100mm)           |
|---------|------------------|------------------------------------------------|
|     HIERARCHY SECTION                                                       |
|     -----------------                                                       |
|   69    |                 1| No hierarchy section in this format            |
|---------|------------------|------------------------------------------------|
|      CHARACTER INDEX                                                        |
|      ---------------                                                        |
|   70    |               408| Length of character index                      |
|   71    |                25| LENGTH OF FONT IN PHYSICAL RECORDS             |
|   72    |              1210| Last word of last record                       |
|         |                  |                                                |
|   73    |               101| Character number:  1                           |
|   74    |                 1| Pointer to record containing start of character|
|   75    |               478| Word pointer to start of character             |
|         |                  |                                                |
|   76    |               102| Ch. no.: 2                                     |
|   77    |                 1| Record pointer                                 |
|   78    |               752| Word pointer                                   |
|         |                  |                                                |
|  79-  81|   103      1 1267| No., record pointer, word pointer of ch.:    3 |
|  82-  84|   104      1 1639| No., record pointer, word pointer of ch.:    4 |
|  85-  87|   105      1 1968| No., record pointer, word pointer of ch.:    5 |
|  88-  90|   106      2  248| No., record pointer, word pointer of ch.:    6 |
|  91-  93|   107      2  558| No., record pointer, word pointer of ch.:    7 |
|  94-  96|   108      2 1053| No., record pointer, word pointer of ch.:    8 |
|  97-  99|   109      2 1459| No., record pointer, word pointer of ch.:    9 |
| 100- 102|   110      2 1665| No., record pointer, word pointer of ch.:   10 |
| 103- 105|   111      2 1904| No., record pointer, word pointer of ch.:   11 |
| 106- 108|   112      3  247| No., record pointer, word pointer of ch.:   12 |
|---------|------------------|------------------------------------------------|
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 |---------|------------------|----------------------------------------------|
 | WORDNO. |     CONTENT      |                   COMMENT                    |
 |---------|------------------|----------------------------------------------|
 | 109- 111|  113      3  477 | No., record pointer, word pointer of ch.:  13|
 | 112- 114|  114      3  816 | No., record pointer, word pointer of ch.:  14|
 | 115- 117|  115      3 1111 | No., record pointer, word pointer of ch.:  15|
 | 118- 120|  116      3 1470 | No., record pointer, word pointer of ch.:  16|
 | 121- 123|  117      3 1843 | No., record pointer, word pointer of ch.:  17|
 | 124- 126|  118      4  313 | No., record pointer, word pointer of ch.:  18|
 | 127- 129|  119      4  905 | No., record pointer, word pointer of ch.:  19|
 | 130- 132|  120      4 1408 | No., record pointer, word pointer of ch.:  20|
 | 133- 135|  121      4 1641 | No., record pointer, word pointer of ch.:  21|
 | 136- 138|  122      5    6 | No., record pointer, word pointer of ch.:  22|
 | 139- 141|  123      5  230 | No., record pointer, word pointer of ch.:  23|
 | 142- 144|  124      5  520 | No., record pointer, word pointer of ch.:  24|
 | 145- 147|  125      5  967 | No., record pointer, word pointer of ch.:  25|
 | 148- 150|  126      5 1282 | No., record pointer, word pointer of ch.:  26|
 | 151- 153|  127      5 1446 | No., record pointer, word pointer of ch.:  27|
 | 154- 156|  128      5 1909 | No., record pointer, word pointer of ch.:  28|
 | 157- 159|  129      6  370 | No., record pointer, word pointer of ch.:  29|
 | 160- 162|  201      6  834 | No., record pointer, word pointer of ch.:  30|
 | 163- 165|  208      6 1207 | No., record pointer, word pointer of ch.:  31|
 | 166- 168|  210      6 1580 | No., record pointer, word pointer of ch.:  32|
 | 169- 171|  237      7   88 | No., record pointer, word pointer of ch.:  33|
 | 172- 174|  251      7  705 | No., record pointer, word pointer of ch.:  34|
 | 175- 177|  301      7 1376 | No., record pointer, word pointer of ch.:  35|
 | 178- 180|  302      7 2029 | No., record pointer, word pointer of ch.:  36|

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 |---------|------------------|----------------------------------------------|
 | WORDNO. |     CONTENT      |                   COMMENT                    |
 |---------|------------------|----------------------------------------------|
 | 286- 288|  502     16  924 | No., record pointer, word pointer of ch.:  72|
 | 289- 291|  503     16 1412 | No., record pointer, word pointer of ch.:  73|
 | 292- 294|  504     16 1862 | No., record pointer, word pointer of ch.:  74|
 | 295- 297|  505     16 1961 | No., record pointer, word pointer of ch.:  75|
 | 298- 300|  506     17  453 | No., record pointer, word pointer of ch.:  76|
 | 301- 303|  507     17 1047 | No., record pointer, word pointer of ch.:  77|
 | 304- 306|  508     17 1275 | No., record pointer, word pointer of ch.:  78|
 | 307- 309|  509     17 1961 | No., record pointer, word pointer of ch.:  79|
 | 310- 312|  510     18  524 | No., record pointer, word pointer of ch.:  80|
 | 313- 315|  511     18  883 | No., record pointer, word pointer of ch.:  81|
 | 316- 318|  512     18 1770 | No., record pointer, word pointer of ch.:  82|
 | 319- 321|  513     19  501 | No., record pointer, word pointer of ch.:  83|
 | 322- 324|  601     19  979 | No., record pointer, word pointer of ch.:  84|
 | 325- 327|  602     19 1049 | No., record pointer, word pointer of ch.:  85|
 | 328- 330|  603     19 1168 | No., record pointer, word pointer of ch.:  86|
 | 331- 333|  604     19 1238 | No., record pointer, word pointer of ch.:  87|

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 |---------|------------------|----------------------------------------------|
 | WORDNO. |     CONTENT      |                   COMMENT                    |
 |---------|------------------|----------------------------------------------|
 | 463- 465|  754     25  466 | No., record pointer, word pointer of ch.: 131|
 | 466- 468|  755     25  575 | No., record pointer, word pointer of ch.: 132|
 | 469- 471|  756     25  684 | No., record pointer, word pointer of ch.: 133|
 | 472- 474|  759     25  732 | No., record pointer, word pointer of ch.: 134|
 | 475- 477|  761     25 1003 | No., record pointer, word pointer of ch.: 135|
 |         |                  |                                              |
 |---------|------------------|----------------------------------------------|
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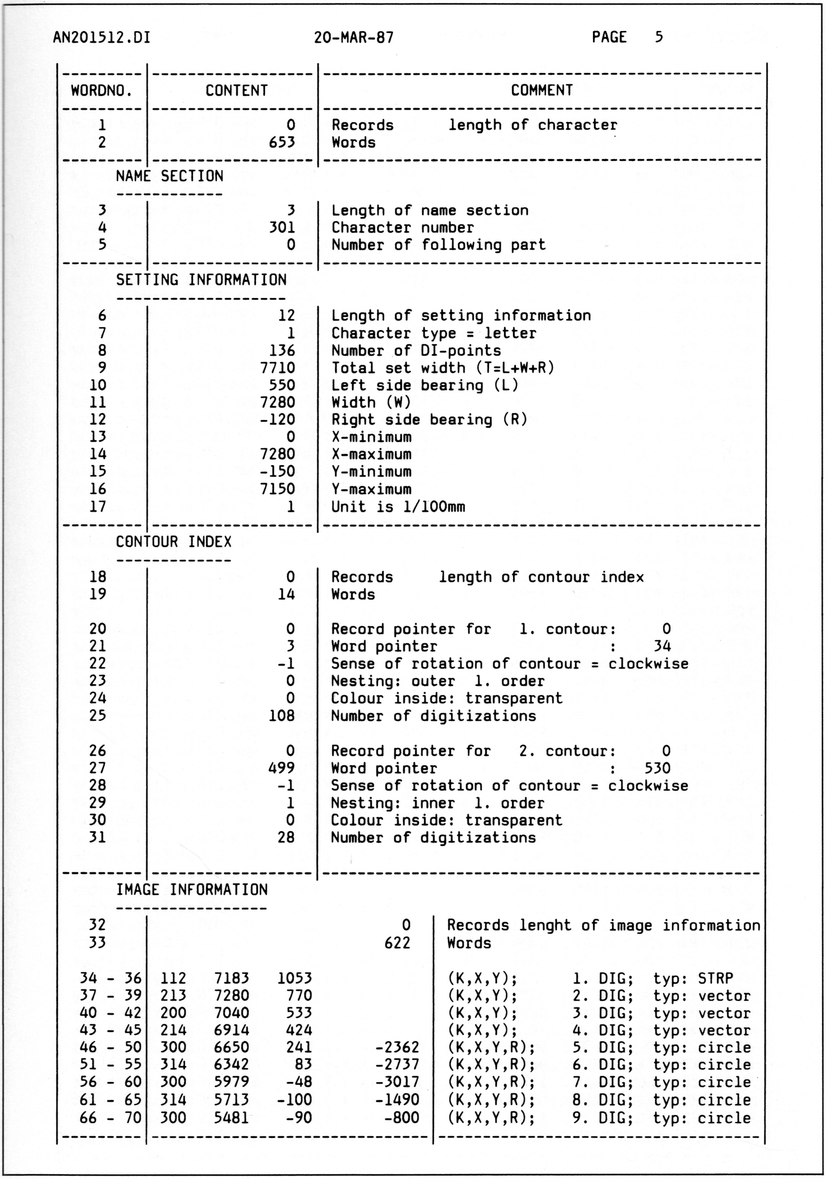

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|---------|------------------|---------------------------------------------------|
| WORDNO. |     CONTENT      |                      COMMENT                      |
|---------|------------------|---------------------------------------------------|
|    1    |                0 | Records      length of character                  |
|    2    |              653 | Words                                             |
|---------|------------------|---------------------------------------------------|
|      NAME SECTION                                                              |
|      ------------                                                              |
|    3    |                3 | Length of name section                            |
|    4    |              301 | Character number                                  |
|    5    |                0 | Number of following part                          |
|---------|------------------|---------------------------------------------------|
|      SETTING INFORMATION                                                       |
|      -------------------                                                       |
|    6    |               12 | Length of setting information                     |
|    7    |                1 | Character type = letter                           |
|    8    |              136 | Number of DI-points                               |
|    9    |             7710 | Total set width (T=L+W+R)                         |
|   10    |              550 | Left side bearing (L)                             |
|   11    |             7280 | Width (W)                                         |
|   12    |             -120 | Right side bearing (R)                            |
|   13    |                0 | X-minimum                                         |
|   14    |             7280 | X-maximum                                         |
|   15    |             -150 | Y-minimum                                         |
|   16    |             7150 | Y-maximum                                         |
|   17    |                1 | Unit is 1/100mm                                   |
|---------|------------------|---------------------------------------------------|
|      CONTOUR INDEX                                                             |
|      -------------                                                             |
|   18    |                0 | Records     length of contour index               |
|   19    |               14 | Words                                             |
|         |                  |                                                   |
|   20    |                0 | Record pointer for   1. contour:     0            |
|   21    |                3 | Word pointer                     :    34          |
|   22    |               -1 | Sense of rotation of contour = clockwise          |
|   23    |                0 | Nesting: outer  1. order                          |
|   24    |                0 | Colour inside: transparent                        |
|   25    |              108 | Number of digitizations                           |
|         |                  |                                                   |
|   26    |                0 | Record pointer for   2. contour:     0            |
|   27    |              499 | Word pointer                     :   530          |
|   28    |               -1 | Sense of rotation of contour = clockwise          |
|   29    |                1 | Nesting: inner  1. order                          |
|   30    |                0 | Colour inside: transparent                        |
|   31    |               28 | Number of digitizations                           |
|         |                  |                                                   |
|---------|------------------|---------------------------------------------------|
|      IMAGE INFORMATION                                                         |
|      -----------------                                                         |
|   32    |                              0 | Records lenght of image information |
|   33    |                            622 | Words                               |
|         |                                |                                     |
| 34 - 36 | 112   7183   1053              | (K,X,Y);       1. DIG;  typ: STRP   |
| 37 - 39 | 213   7280    770              | (K,X,Y);       2. DIG;  typ: vector |
| 40 - 42 | 200   7040    533              | (K,X,Y);       3. DIG;  typ: vector |
| 43 - 45 | 214   6914    424              | (K,X,Y);       4. DIG;  typ: vector |
| 46 - 50 | 300   6650    241      -2362   | (K,X,Y,R);     5. DIG;  typ: circle |
| 51 - 55 | 314   6342     83      -2737   | (K,X,Y,R);     6. DIG;  typ: circle |
| 56 - 60 | 300   5979    -48      -3017   | (K,X,Y,R);     7. DIG;  typ: circle |
| 61 - 65 | 314   5713   -100      -1490   | (K,X,Y,R);     8. DIG;  typ: circle |
| 66 - 70 | 300   5481    -90       -800   | (K,X,Y,R);     9. DIG;  typ: circle |
|---------|--------------------------------|-------------------------------------|
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 |---------|-------------------------------|-----------------------------------|
 | WORDNO. |            CONTENT            |              COMMENT              |
 |---------|-------------------------------|-----------------------------------|
 |  71 - 75| 314  5214     -4        -1170 | (K,X,Y,R);   10. DIG;   typ: circle
 |  76 - 80| 300  4970    149        -1118 | (K,X,Y,R);   11. DIG;   typ: circle
 |  81 - 85| 314  4794    342         -915 | (K,X,Y,R);   12. DIG;   typ: circle
 |  86 - 90| 300  4677    549        -1458 | (K,X,Y,R);   13. DIG;   typ: circle
 |  91 - 95| 314  4582    801        -1880 | (K,X,Y,R);   14. DIG;   typ: circle
 |  96 - 98| 213  4512   1053              | (K,X,Y);     15. DIG;   typ: vector
 |  99 -101| 213  4427   1053              | (K,X,Y);     16. DIG;   typ: vector
 | 102 -104| 200  4195    809              | (K,X,Y);     17. DIG;   typ: vector
 | 105 -107| 214  4074    691              | (K,X,Y);     18. DIG;   typ: vector
 | 108 -112| 300  3789    453        -3431 | (K,X,Y,R);   19. DIG;   typ: circle
 | 113 -117| 314  3490    255        -3212 | (K,X,Y,R);   20. DIG;   typ: circle
 | 118 -122| 300  3109     66        -3116 | (K,X,Y,R);   21. DIG;   typ: circle
 | 123 -127| 314  2723    -63        -2864 | (K,X,Y,R);   22. DIG;   typ: circle
 | 128 -132| 300  2391   -127        -2784 | (K,X,Y,R);   23. DIG;   typ: circle
 | 133 -137| 314  2054   -150        -2793 | (K,X,Y,R);   24. DIG;   typ: circle
 | 138 -142| 300  1484    -89        -2518 | (K,X,Y,R);   25. DIG;   typ: circle
 | 143 -147| 314   990     88        -2108 | (K,X,Y,R);   26. DIG;   typ: circle
 | 148 -152| 300   515    440        -1766 | (K,X,Y,R);   27. DIG;   typ: circle
 | 153 -157| 314   195    917        -1660 | (K,X,Y,R);   28. DIG;   typ: circle
 | 158 -162| 300    45   1393        -2216 | (K,X,Y,R);   29. DIG;   typ: circle
 | 163 -167| 314     0   1924        -2522 | (K,X,Y,R);   30. DIG;   typ: circle
 | 168 -172| 300    40   2322        -2477 | (K,X,Y,R);   31. DIG;   typ: circle
 | 173 -177| 314   137   2669        -2015 | (K,X,Y,R);   32. DIG;   typ: circle
 | 178 -182| 300   314   3010        -1646 | (K,X,Y,R);   33. DIG;   typ: circle
 | 183 -187| 314   541   3266        -1307 | (K,X,Y,R);   34. DIG;   typ: circle
 | 188 -192| 300   992   3575        -2420 | (K,X,Y,R);   35. DIG;   typ: circle
 | 193 -197| 314  1529   3789        -2708 | (K,X,Y,R);   36. DIG;   typ: circle
 | 198 -202| 300  1985   3901        -7283 | (K,X,Y,R);   37. DIG;   typ: circle
 | 203 -207| 314  2522   3999        -9806 | (K,X,Y,R);   38. DIG;   typ: circle
 | 208 -210| 215  3093   4089              | (K,X,Y);     39. DIG;   typ: vector
 | 211 -213| 213  4369   4318              | (K,X,Y);     40. DIG;   typ: vector
 | 214 -216| 213  4490   4484              | (K,X,Y);     41. DIG;   typ: vector
 | 217 -219| 200  4485   4785              | (K,X,Y);     42. DIG;   typ: vector
 | 220 -222| 214  4478   4935              | (K,X,Y);     43. DIG;   typ: vector
 | 223 -227| 300  4444   5225         3297 | (K,X,Y,R);   44. DIG;   typ: circle
 | 228 -232| 314  4384   5514         3362 | (K,X,Y,R);   45. DIG;   typ: circle
 | 233 -237| 300  4216   5975         2451 | (K,X,Y,R);   46. DIG;   typ: circle
 | 238 -242| 314  4018   6273         1300 | (K,X,Y,R);   47. DIG;   typ: circle
 | 243 -247| 300  3789   6463          978 | (K,X,Y,R);   48. DIG;   typ: circle
 | 248 -252| 314  3441   6619         1608 | (K,X,Y,R);   49. DIG;   typ: circle
 | 253 -257| 300  3151   6683         1757 | (K,X,Y,R);   50. DIG;   typ: circle
 | 258 -262| 314  2850   6698         1799 | (K,X,Y,R);   51. DIG;   typ: circle
 | 263 -267| 300  2628   6676         1796 | (K,X,Y,R);   52. DIG;   typ: circle
 | 268 -272| 314  2420   6629         1629 | (K,X,Y,R);   53. DIG;   typ: circle
 | 273 -275| 200  2289   6583              | (K,X,Y);     54. DIG;   typ: vector
 | 276 -278| 214  2184   6534              | (K,X,Y);     55. DIG;   typ: vector
 | 279 -281| 200  2115   6492              | (K,X,Y);     56. DIG;   typ: vector
 | 282 -284| 214  2049   6444              | (K,X,Y);     57. DIG;   typ: vector
 | 285 -289| 300  1976   6368          415 | (K,X,Y,R);   58. DIG;   typ: circle
 | 290 -294| 314  1961   6325           79 | (K,X,Y,R);   59. DIG;   typ: circle
 | 295 -299| 300  1971   6282           80 | (K,X,Y,R);   60. DIG;   typ: circle
 | 300 -304| 314  2024   6213          306 | (K,X,Y,R);   61. DIG;   typ: circle
 | 305 -307| 214  2154   6086              | (K,X,Y);     62. DIG;   typ: vector
 | 308 -312| 300  2237   5985         -593 | (K,X,Y,R);   63. DIG;   typ: circle
 | 313 -317| 314  2301   5860         -691 | (K,X,Y,R);   64. DIG;   typ: circle
 | 318 -322| 300  2339   5726         -732 | (K,X,Y,R);   65. DIG;   typ: circle
 | 323 -327| 314  2352   5583         -777 | (K,X,Y,R);   66. DIG;   typ: circle
 | 328 -332| 300  2327   5380         -851 | (K,X,Y,R);   67. DIG;   typ: circle
 | 333 -337| 314  2255   5192         -832 | (K,X,Y,R);   68. DIG;   typ: circle
 |---------|-------------------------------|-----------------------------------|
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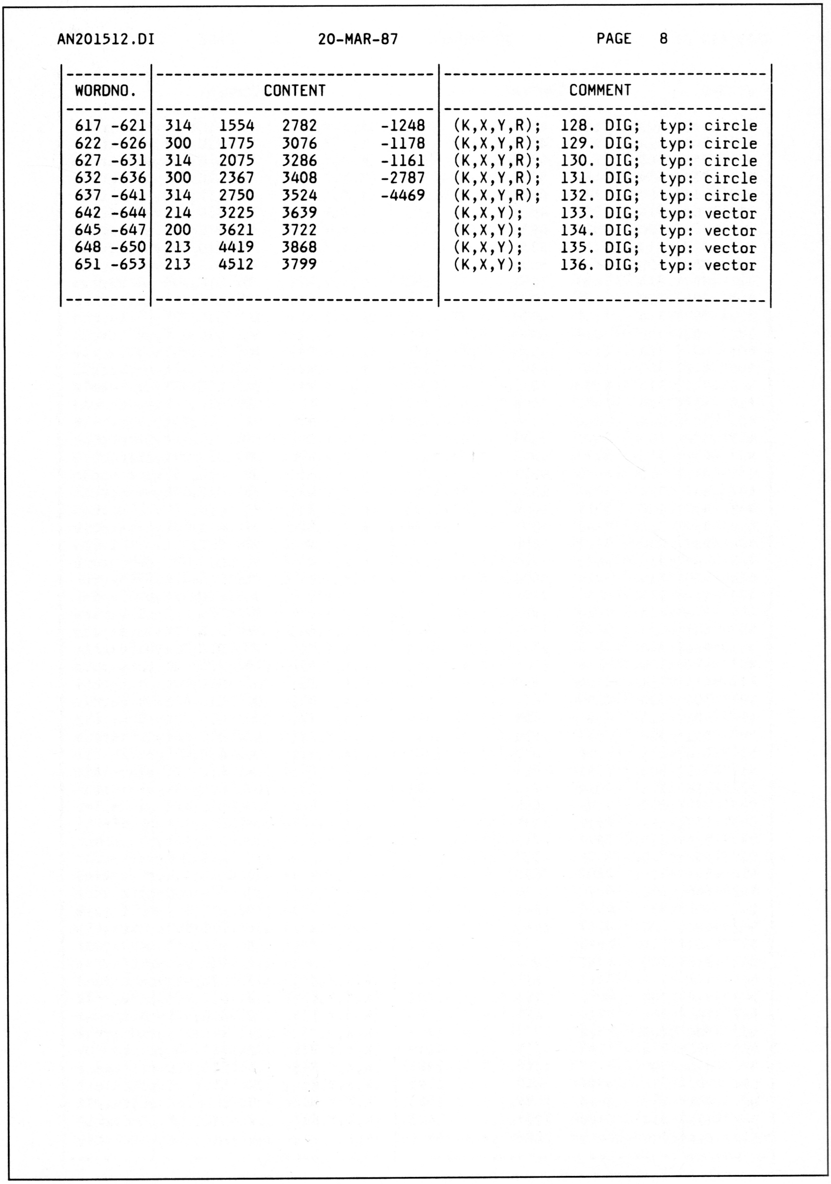
 WORDNO.               CONTENT                           COMMENT
 ---------  ------------------------------  ---------------------------------
 338 -342   300   2110   4993         -862   (K,X,Y,R);    69. DIG;  typ: circle
 343 -347   314   1930   4859         -713   (K,X,Y,R);    70. DIG;  typ: circle
 348 -352   300   1720   4782         -849   (K,X,Y,R);    71. DIG;  typ: circle
 353 -357   314   1468   4757        -1083   (K,X,Y,R);    72. DIG;  typ: circle
 358 -362   300   1273   4778        -1058   (K,X,Y,R);    73. DIG;  typ: circle
 363 -367   314   1122   4828         -693   (K,X,Y,R);    74. DIG;  typ: circle
 368 -372   300    897   4988         -741   (K,X,Y,R);    75. DIG;  typ: circle
 373 -377   314    734   5233         -839   (K,X,Y,R);    76. DIG;  typ: circle
 378 -382   300    667   5454         -977   (K,X,Y,R);    77. DIG;  typ: circle
 383 -387   314    653   5692        -1036   (K,X,Y,R);    78. DIG;  typ: circle
 388 -392   300    682   5891        -1139   (K,X,Y,R);    79. DIG;  typ: circle
 393 -397   314    747   6089        -1220   (K,X,Y,R);    80. DIG;  typ: circle
 398 -402   300    919   6386        -1408   (K,X,Y,R);    81. DIG;  typ: circle
 403 -407   314   1141   6610        -1193   (K,X,Y,R);    82. DIG;  typ: circle
 408 -412   300   1541   6855        -2182   (K,X,Y,R);    83. DIG;  typ: circle
 413 -417   314   2000   7017        -2345   (K,X,Y,R);    84. DIG;  typ: circle
 418 -422   300   2482   7106        -4739   (K,X,Y,R);    85. DIG;  typ: circle
 423 -427   314   3008   7150        -5505   (K,X,Y,R);    86. DIG;  typ: circle
 428 -432   300   3631   7135        -5309   (K,X,Y,R);    87. DIG;  typ: circle
 433 -437   314   4197   7052        -4472   (K,X,Y,R);    88. DIG;  typ: circle
 438 -442   300   4675   6895        -2353   (K,X,Y,R);    89. DIG;  typ: circle
 443 -447   314   5056   6664        -1852   (K,X,Y,R);    90. DIG;  typ: circle
 448 -452   300   5399   6308        -1796   (K,X,Y,R);    91. DIG;  typ: circle
 453 -457   314   5640   5861        -1888   (K,X,Y,R);    92. DIG;  typ: circle
 458 -462   300   5772   5396        -2904   (K,X,Y,R);    93. DIG;  typ: circle
 463 -467   314   5812   4979        -2177   (K,X,Y,R);    94. DIG;  typ: circle
 468 -470   215   5812   4506                (K,X,Y);      95. DIG;  typ: vector
 471 -473   215   5812   2271                (K,X,Y);      96. DIG;  typ: vector
 474 -476   214   5819   1892                (K,X,Y);      97. DIG;  typ: vector
 477 -481   300   5838   1592         4908   (K,X,Y,R);    98. DIG;  typ: circle
 482 -486   314   5868   1377         2548   (K,X,Y,R);    99. DIG;  typ: circle
 487 -491   300   5969   1102          851   (K,X,Y,R);   100. DIG;  typ: circle
 492 -496   314   6134    919          599   (K,X,Y,R);   101. DIG;  typ: circle
 497 -501   300   6299    835          577   (K,X,Y,R);   102. DIG;  typ: circle
 502 -506   314   6481    808          574   (K,X,Y,R);   103. DIG;  typ: circle
 507 -511   300   6632    821         1012   (K,X,Y,R);   104. DIG;  typ: circle
 512 -516   314   6798    860         1285   (K,X,Y,R);   105. DIG;  typ: circle
 517 -521   300   6951    915         1597   (K,X,Y,R);   106. DIG;  typ: circle
 522 -526   314   7060    970          891   (K,X,Y,R);   107. DIG;  typ: circle
 527 -529   213   7183   1053                (K,X,Y);     108. DIG;  typ: vector
 530 -532   112   4512   3799                (K,X,Y);     109. DIG;  typ: STRP
 533 -535   215   4512   2715                (K,X,Y);     110. DIG;  typ: vector
 536 -538   200   4506   2503                (K,X,Y);     111. DIG;  typ: vector
 539 -541   214   4487   2283                (K,X,Y);     112. DIG;  typ: vector
 542 -546   300   4427   1930        -3242   (K,X,Y,R);   113. DIG;  typ: circle
 547 -551   314   4350   1681        -1713   (K,X,Y,R);   114. DIG;  typ: circle
 552 -556   300   4237   1465        -1159   (K,X,Y,R);   115. DIG;  typ: circle
 557 -561   314   4055   1237        -1667   (K,X,Y,R);   116. DIG;  typ: circle
 562 -566   300   3780   1002        -1809   (K,X,Y,R);   117. DIG;  typ: circle
 567 -571   314   3461    823        -1853   (K,X,Y,R);   118. DIG;  typ: circle
 572 -576   300   3095    707        -1840   (K,X,Y,R);   119. DIG;  typ: circle
 577 -581   314   2717    671        -1791   (K,X,Y,R);   120. DIG;  typ: circle
 582 -586   300   2320    727        -1553   (K,X,Y,R);   121. DIG;  typ: circle
 587 -591   314   1989    872        -1263   (K,X,Y,R);   122. DIG;  typ: circle
 592 -596   300   1707   1110        -1283   (K,X,Y,R);   123. DIG;  typ: circle
 597 -601   314   1520   1401        -1122   (K,X,Y,R);   124. DIG;  typ: circle
 602 -606   300   1417   1731        -1524   (K,X,Y,R);   125. DIG;  typ: circle
 607 -611   314   1389   2087        -1623   (K,X,Y,R);   126. DIG;  typ: circle
 612 -616   300   1442   2485        -1997   (K,X,Y,R);   127. DIG;  typ: circle
 ---------  ------------------------------  ---------------------------------
```



```
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 |---------|-------------------------------|-------------------------------------|
 | WORDNO. |            CONTENT            |               COMMENT               |
 |---------|-------------------------------|-------------------------------------|
 | 617 -621| 314    1554    2782      -1248| (K,X,Y,R);  128. DIG;  typ: circle  |
 | 622 -626| 300    1775    3076      -1178| (K,X,Y,R);  129. DIG;  typ: circle  |
 | 627 -631| 314    2075    3286      -1161| (K,X,Y,R);  130. DIG;  typ: circle  |
 | 632 -636| 300    2367    3408      -2787| (K,X,Y,R);  131. DIG;  typ: circle  |
 | 637 -641| 314    2750    3524      -4469| (K,X,Y,R);  132. DIG;  typ: circle  |
 | 642 -644| 214    3225    3639           | (K,X,Y);    133. DIG;  typ: vector  |
 | 645 -647| 200    3621    3722           | (K,X,Y);    134. DIG;  typ: vector  |
 | 648 -650| 213    4419    3868           | (K,X,Y);    135. DIG;  typ: vector  |
 | 651 -653| 213    4512    3799           | (K,X,Y);    136. DIG;  typ: vector  |
 |         |                               |                                     |
 |---------|-------------------------------|-------------------------------------|
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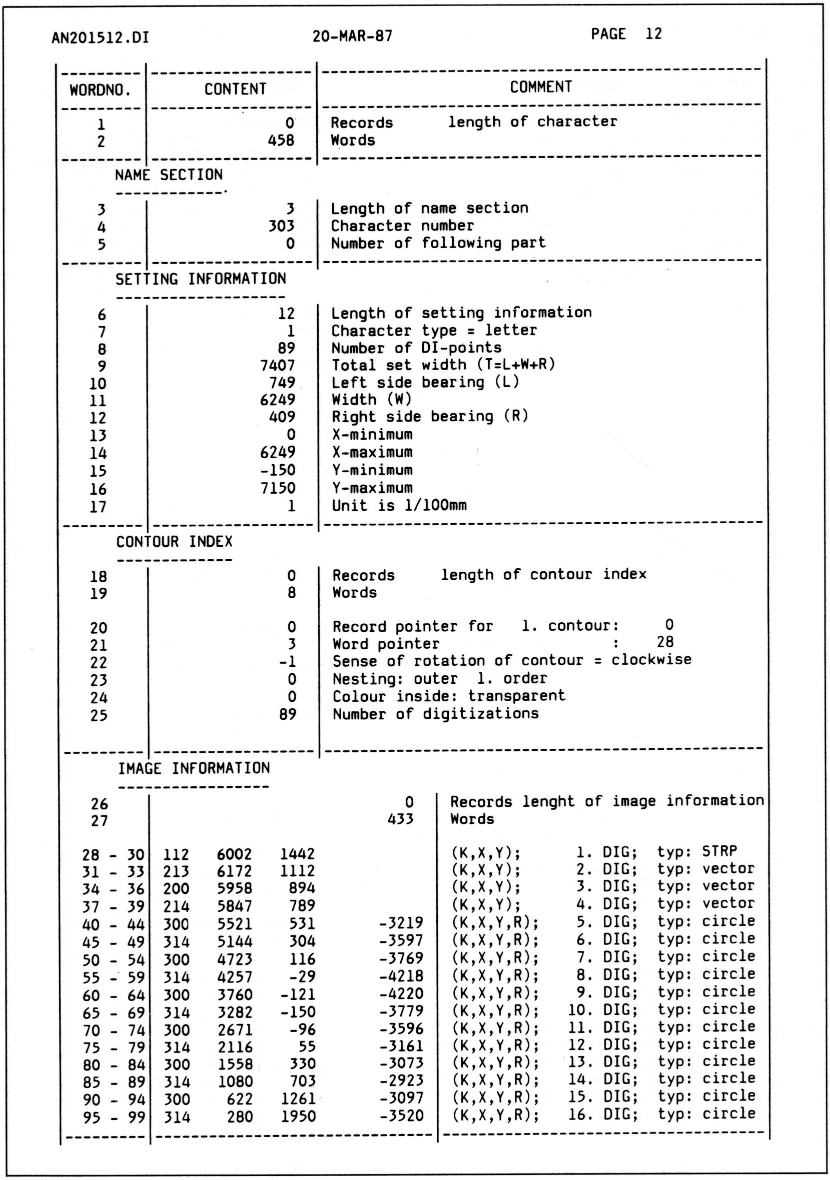
|---------|------------------|---------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                       |
|---------|------------------|---------------------------------------------------|
|    1    |                0 | Records      length of character                  |
|    2    |              444 | Words                                             |
|---------|------------------|---------------------------------------------------|
       NAME SECTION
       ------------
     3    |                3 | Length of name section
     4    |              302 | Character number
     5    |                0 | Number of following part
 ---------|------------------|---------------------------------------------------
       SETTING INFORMATION
       -------------------
     6    |               12 | Length of setting information
     7    |                1 | Character type = letter
     8    |               89 | Number of DI-points
     9    |             9637 | Total set width (T=L+W+R)
    10    |                0 | Left side bearing (L)
    11    |             8887 | Width (W)
    12    |              750 | Right side bearing (R)
    13    |                0 | X-minimum
    14    |             8887 | X-maximum
    15    |             -200 | Y-minimum
    16    |            10500 | Y-maximum
    17    |                1 | Unit is 1/100mm
 ---------|------------------|---------------------------------------------------
       CONTOUR INDEX
       -------------
    18    |                0 | Records     length of contour index
    19    |               14 | Words
          |                  |
    20    |                0 | Record pointer for   1. contour:     0
    21    |                3 | Word pointer                   :    34
    22    |               -1 | Sense of rotation of contour = clockwise
    23    |                0 | Nesting: outer  1. order
    24    |                0 | Colour inside: transparent
    25    |               56 | Number of digitizations
          |                  |
    26    |                0 | Record pointer for   2. contour:     0
    27    |              251 | Word pointer                   :   282
    28    |               -1 | Sense of rotation of contour = clockwise
    29    |                1 | Nesting: inner  1. order
    30    |                0 | Colour inside: transparent
    31    |               33 | Number of digitizations
          |                  |
 ---------|------------------|---------------------------------------------------
       IMAGE INFORMATION
       -----------------
    32    |                              0 | Records lenght of image information
    33    |                            413 | Words
          |                                |
  34 - 36 | 112   2004   -200            | (K,X,Y);      1. DIG;  typ: STRP
  37 - 39 | 213   1628   -200            | (K,X,Y);      2. DIG;  typ: vector
  40 - 42 | 215   1628   7996            | (K,X,Y);      3. DIG;  typ: vector
  43 - 45 | 214   1626   8335            | (K,X,Y);      4. DIG;  typ: vector
  46 - 50 | 300   1609   8620       3135 | (K,X,Y,R);    5. DIG;  typ: circle
  51 - 55 | 314   1570   8866       2401 | (K,X,Y,R);    6. DIG;  typ: circle
  56 - 60 | 300   1481   9120       1045 | (K,X,Y,R);    7. DIG;  typ: circle
  61 - 65 | 314   1362   9278        561 | (K,X,Y,R);    8. DIG;  typ: circle
  66 - 70 | 300   1203   9387        657 | (K,X,Y,R);    9. DIG;  typ: circle
|---------|--------------------------------|------------------------------------|
```



```
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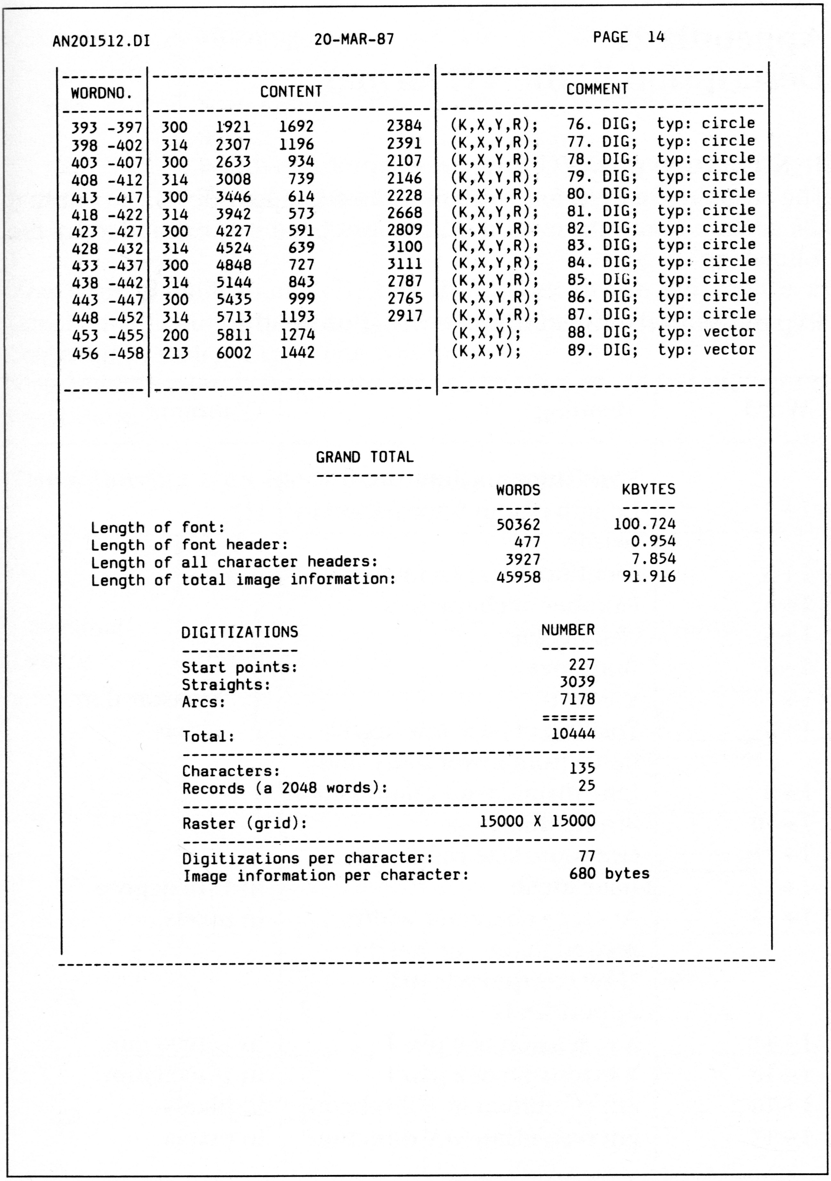
 |---------|------------------|--------------------------------------------|
 | WORDNO. |      CONTENT     |                  COMMENT                   |
 |---------|------------------|--------------------------------------------|
 |    1    |                 0|  Records      length of character          |
 |    2    |               458|  Words                                     |
 |---------|------------------|--------------------------------------------|
 |     NAME SECTION                                                        |
 |     ------------.                                                       |
 |    3    |                 3|  Length of name section                    |
 |    4    |               303|  Character number                          |
 |    5    |                 0|  Number of following part                  |
 |---------|------------------|--------------------------------------------|
 |     SETTING INFORMATION                                                 |
 |     -------------------                                                 |
 |    6    |                12|  Length of setting information             |
 |    7    |                 1|  Character type = letter                   |
 |    8    |                89|  Number of DI-points                       |
 |    9    |              7407|  Total set width (T=L+W+R)                 |
 |   10    |               749|  Left side bearing (L)                     |
 |   11    |              6249|  Width (W)                                 |
 |   12    |               409|  Right side bearing (R)                    |
 |   13    |                 0|  X-minimum                                 |
 |   14    |              6249|  X-maximum                                 |
 |   15    |              -150|  Y-minimum                                 |
 |   16    |              7150|  Y-maximum                                 |
 |   17    |                 1|  Unit is 1/100mm                           |
 |---------|------------------|--------------------------------------------|
 |     CONTOUR INDEX                                                       |
 |     -------------                                                       |
 |   18    |                 0|  Records     length of contour index       |
 |   19    |                 8|  Words                                     |
 |         |                  |                                            |
 |   20    |                 0|  Record pointer for   1. contour:     0     |
 |   21    |                 3|  Word pointer                   :    28     |
 |   22    |                -1|  Sense of rotation of contour = clockwise  |
 |   23    |                 0|  Nesting: outer  1. order                  |
 |   24    |                 0|  Colour inside: transparent                |
 |   25    |                89|  Number of digitizations                   |
 |         |                  |                                            |
 |---------|------------------|--------------------------------------------|
 |     IMAGE INFORMATION                                                   |
 |     -----------------                                                   |
 |   26    |                             0|  Records lenght of image information
 |   27    |                           433|  Words                          |
 |         |                              |                                 |
 | 28 - 30 | 112   6002   1442            |  (K,X,Y);      1. DIG;  typ: STRP
 | 31 - 33 | 213   6172   1112            |  (K,X,Y);      2. DIG;  typ: vector
 | 34 - 36 | 200   5958    894            |  (K,X,Y);      3. DIG;  typ: vector
 | 37 - 39 | 214   5847    789            |  (K,X,Y);      4. DIG;  typ: vector
 | 40 - 44 | 300   5521    531       -3219|  (K,X,Y,R);    5. DIG;  typ: circle
 | 45 - 49 | 314   5144    304       -3597|  (K,X,Y,R);    6. DIG;  typ: circle
 | 50 - 54 | 300   4723    116       -3769|  (K,X,Y,R);    7. DIG;  typ: circle
 | 55 - 59 | 314   4257    -29       -4218|  (K,X,Y,R);    8. DIG;  typ: circle
 | 60 - 64 | 300   3760   -121       -4220|  (K,X,Y,R);    9. DIG;  typ: circle
 | 65 - 69 | 314   3282   -150       -3779|  (K,X,Y,R);   10. DIG;  typ: circle
 | 70 - 74 | 300   2671    -96       -3596|  (K,X,Y,R);   11. DIG;  typ: circle
 | 75 - 79 | 314   2116     55       -3161|  (K,X,Y,R);   12. DIG;  typ: circle
 | 80 - 84 | 300   1558    330       -3073|  (K,X,Y,R);   13. DIG;  typ: circle
 | 85 - 89 | 314   1080    703       -2923|  (K,X,Y,R);   14. DIG;  typ: circle
 | 90 - 94 | 300    622   1261       -3097|  (K,X,Y,R);   15. DIG;  typ: circle
 | 95 - 99 | 314    280   1950       -3520|  (K,X,Y,R);   16. DIG;  typ: circle
 |---------|------------------------------|---------------------------------|
```



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 ---------|--------------------------------|---------------------------------------
  WORDNO. |            CONTENT             |               COMMENT
 ---------|--------------------------------|---------------------------------------
 393 -397 | 300   1921   1692         2384 | (K,X,Y,R);    76. DIG;   typ: circle
 398 -402 | 314   2307   1196         2391 | (K,X,Y,R);    77. DIG;   typ: circle
 403 -407 | 300   2633    934         2107 | (K,X,Y,R);    78. DIG;   typ: circle
 408 -412 | 314   3008    739         2146 | (K,X,Y,R);    79. DIG;   typ: circle
 413 -417 | 300   3446    614         2228 | (K,X,Y,R);    80. DIG;   typ: circle
 418 -422 | 314   3942    573         2668 | (K,X,Y,R);    81. DIG;   typ: circle
 423 -427 | 300   4227    591         2809 | (K,X,Y,R);    82. DIG;   typ: circle
 428 -432 | 314   4524    639         3100 | (K,X,Y,R);    83. DIG;   typ: circle
 433 -437 | 300   4848    727         3111 | (K,X,Y,R);    84. DIG;   typ: circle
 438 -442 | 314   5144    843         2787 | (K,X,Y,R);    85. DIG;   typ: circle
 443 -447 | 300   5435    999         2765 | (K,X,Y,R);    86. DIG;   typ: circle
 448 -452 | 314   5713   1193         2917 | (K,X,Y,R);    87. DIG;   typ: circle
 453 -455 | 200   5811   1274              | (K,X,Y);      88. DIG;   typ: vector
 456 -458 | 213   6002   1442              | (K,X,Y);      89. DIG;   typ: vector
          |                                |
 ---------|--------------------------------|---------------------------------------


                            GRAND TOTAL
                            -----------
                                                   WORDS        KBYTES
                                                   -----        ------
    Length of font:                                50362       100.724
    Length of font header:                           477         0.954
    Length of all character headers:                3927         7.854
    Length of total image information:             45958        91.916


              DIGITIZATIONS                                NUMBER
              -------------                                ------
              Start points:                                   227
              Straights:                                     3039
              Arcs:                                          7178
                                                           ======
              Total:                                        10444
              -------------------------------------------------
              Characters:                                     135
              Records (a 2048 words):                          25
              -------------------------------------------------
              Raster (grid):                        15000 X 15000
              -------------------------------------------------
              Digitizations per character:                     77
              Image information per character:            680 bytes

 ---------------------------------------------------------------------------------
```

Appendix K
Description of the VC format

1. Structure of a VC font

The structure of a VC font is as described in appendix G, except that the section "font information" in the font header is expanded by the following:

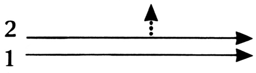
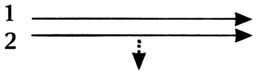
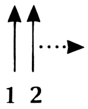
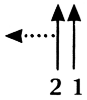
Expanded font information in the font header

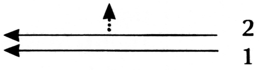
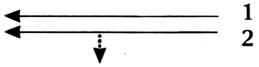
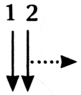
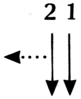
Word	Meaning	Comment
	Font information	
I+2	Length of font information in words	[J]
I+3	Identification of a font	=1
I+4	Number of characters	Measured in pixels
I+5	Cap height	
I+6	Body size	
I+7	x-height	
I+8	Position of base line, as distance from lower body line	
I+9	Line distance for composition	
I+10	Stroke thickness	
I+11	Optimum size range	in p
I+12	Italic angle	in 1/10 degree
I+13	Average character width related to the cap height	in pixels
	New compared with appendix G	
I+14	X extension of a pixel	in 1/1000 mm
I+15	Y extension of a pixel	in 1/1000 mm
I+16	em resolution in X direction	in pixels
I+17	em resolution in Y direction	in pixels

Word	Meaning	Comment
I+18	Scan identification of image data	see below
I+19	Width of printing window	in pixels
I+20	Height of printing window	in pixels

The scan identification describes the corner of the em square in which the scanning of the data was actually started, and also the direction in which a scan line will run.
This identification is important for SC, SN, BI and GS formats and is used there.

The following scan identifications are possible:

Decimal value	Scanning direction	Direction of line advance
11	→	
12	→	
21	↑	
22	↑	

Decimal value	Scanning direction	Direction of line advance
−11	←	
−12	←	
−21	↓	
−22	↓	

Usual values are 21 (CRT machines), 12 (laser printers) and −21 (matrix printers).

The printing window is the frame in which a typesetter can expose. Sometimes laser printers have a smaller printing window than is required for the em of a certain point size. Only then do we describe width and height of the printing window. Normally such details are not necessary.

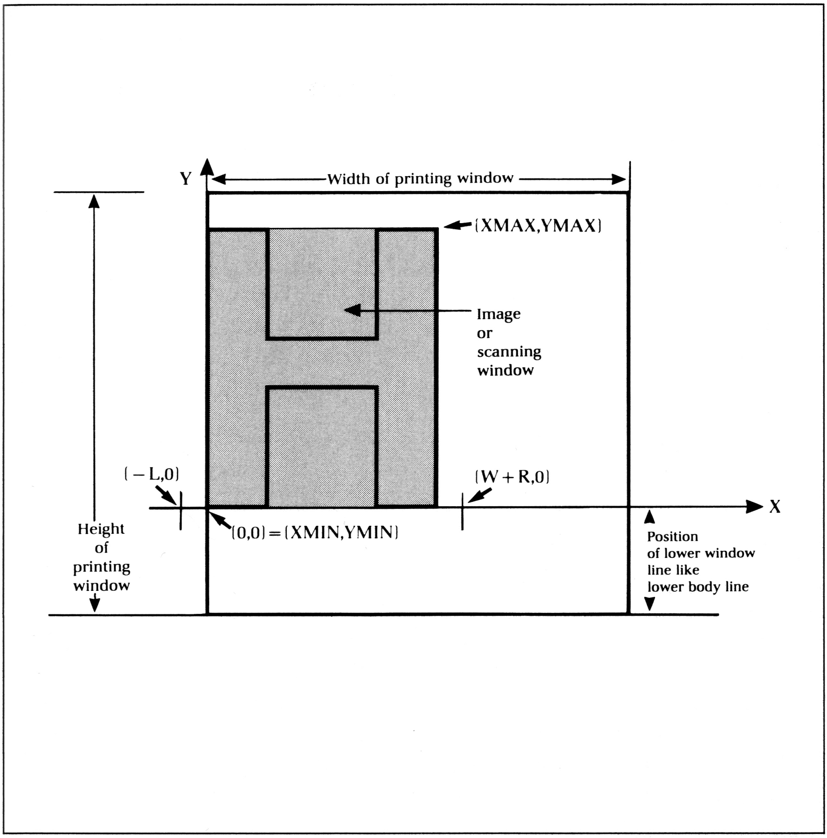
2. Description of the VC format

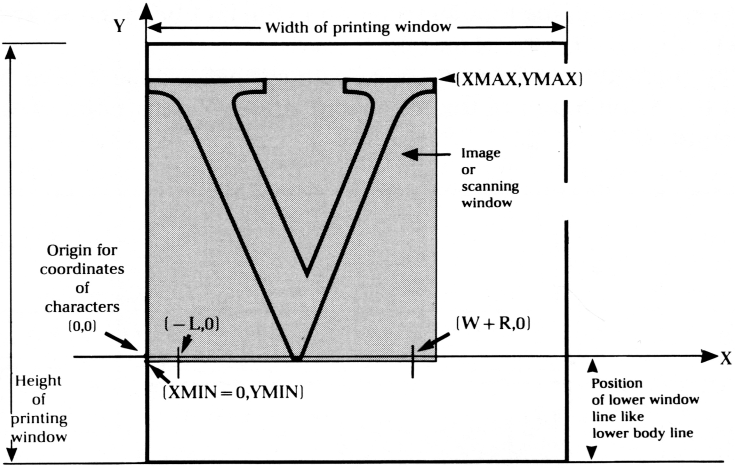
The **vector circle format** was created to produce a compressed version of the DI format. The most undesirable and complicated characteristics of the DI format are the double words used to describe radii. Furthermore, it would be advantageous to have a contour format for typesetting machines which corresponded to the maximum resolution of the machine right from the start. Such machines do not have a 15,000 × 15,000 resolution for the em square but usually something like a 1000 × 1000 raster or even less.

It is thus appropriate to make three important and basic changes to the DI format: the incremental coding, the use of chord heights (instead of radii) to describe circle segments and finally the use of the so-called switches. The unit for chord heights is in quarters of the font unit system.

The expansion of the font information in the font header also applies to VC, VS, VE, SC, SN, BI and GS formats.

Every character has its own coordinate system, whose X zero point is at the X minimum of the letter and whose Y zero point is at the baseline.


Y
Width of printing window
(XMAX,YMAX)
Image or scanning window
(−L,0)
(W+R,0)
X
(0,0) = (XMIN,YMIN)
Height of printing window
Position of lower window line like lower body line


Y
Width of printing window
(XMAX,YMAX)
Image
or
scanning
window
Origin for
coordinates
of
characters
(0,0)
(−L,0)
(W+R,0)
X
(XMIN=0,YMIN)
Height
of
printing
window
Position
of lower window
line like
lower body line

The coding of the straights and circles is done in bytes.
The starting point of the contours is reached with "pen raised" incrementally, with a so-called white vector.
The first white vector of a letter starts at the origin (0,0) of the appropriate coordinate system. The following white vectors start at the ends of preceding contours and lead to following contours in sequence as given in the contour index.
Visible straights are described incrementally as either long or short vectors, circles are described incrementally with a circle vector. We therefore have:

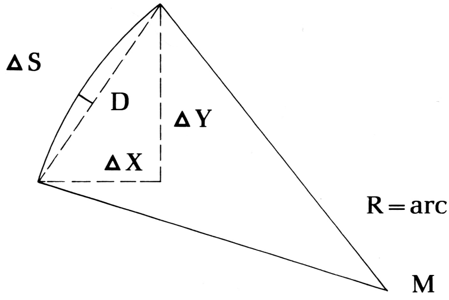
	Switch	ΔX	ΔY	ΔS	Length
W vector		(16 bit)	(16 bit)		=4 bytes
L vector	127,(7F)	(16 bit)	(16 bit)		=4(5) bytes
S vector	126,(7E)	(8 bit)	(8 bit)		=2(3) bytes
C vector	125,(7D)	(8 bit)	(8 bit)	(8 bit)	=3(4) bytes

The bytes with values 127, 126 and 125 (hexadecimal in brackets) are switches. The vector which is switched on applies until it is switched off.

If an increment cannot be described in 16 bits it is divided into describable 16 bit pieces.

The words (16 bit) and bytes (8 bit) are each given a sign. The words are INTEGER × 2, for the bytes: values 0...120 are counted as positive and values 255...136 are counted as negative, as $-1 \ldots -120$. The values of ΔX (8 bit), ΔY (8 bit) and ΔS (8 bit) are thus to be kept smaller than or equal to 120.

Circles are coded in the form of the above mentioned C vectors. ΔS then means the chord height of the related circle segment. If ΔS is positive, the circle turns in an anti-clockwise direction (mathematically positive), if ΔS is negative then it turns in a clockwise direction. The sketch below shows the circle parameters:



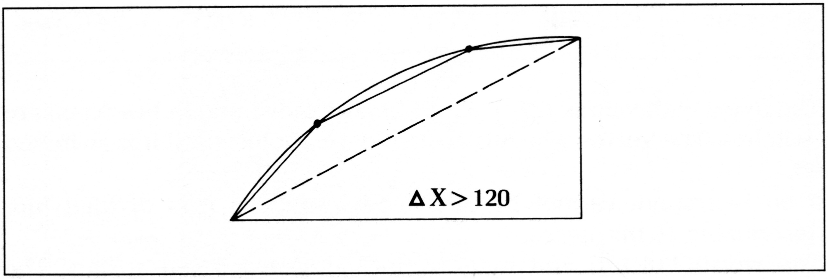
$$D = \sqrt{\Delta X^2 + \Delta Y^2}$$

$$\Delta S = R - \frac{1}{2}\sqrt{4R^2 - D^2}$$

R = arc radius

In order to calculate R (if needed) from ΔS one should use a look-up table (LUT). With this table one can quickly find R as function of ΔS and D.

If a circle (in DI format) has ΔX or $\Delta Y > 120$, then aid points are set along the circle segment such that ΔX and $\Delta Y \leq 120$.



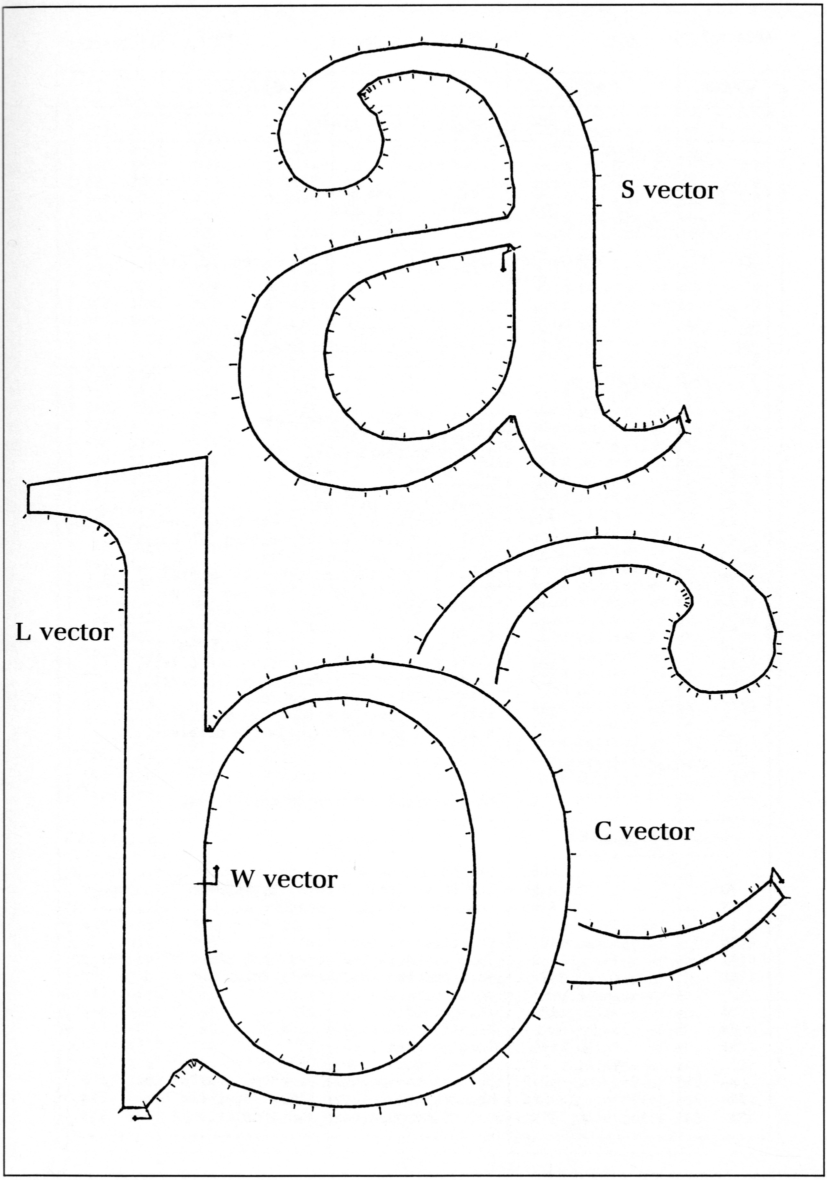
This occurs so rarely that we have not included a long C vector for large circles.

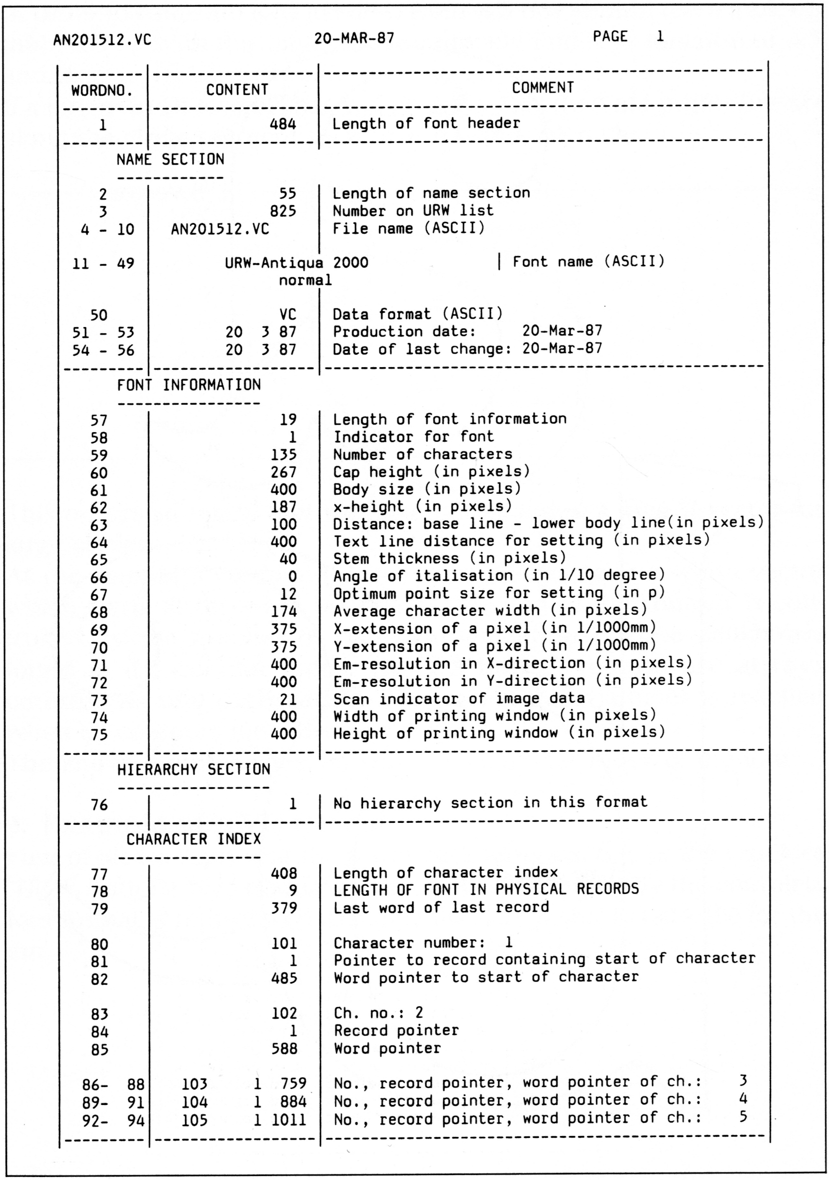
At the start of a contour we therefore always have a white vector which starts at the word boundary. The end of the contour is controlled by the number of vectors (digitizations); these details are found in the contour index. **W, L, S and C vectors are always counted as one digitization.** The end of the character is reached when all contours have been processed.

The end of a font is checked with the character index of the font.

3. Example of a VC format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", with marks. Subsequently the complete font format is reproduced as a data list. The raster is 400 × 400 for the em.


S vector
L vector
C vector
W vector



```
AN201512.VC                    20-MAR-87                     PAGE   1

|---------|------------------|----------------------------------------------------
| WORDNO. |     CONTENT      |                      COMMENT
|---------|------------------|----------------------------------------------------
|    1    |               484| Length of font header
|---------|------------------|----------------------------------------------------
|      NAME SECTION
|      ------------
|    2    |                55| Length of name section
|    3    |               825| Number on URW list
|  4 - 10 |  AN201512.VC     | File name (ASCII)
|
| 11 - 49 |        URW-Antiqua 2000             | Font name (ASCII)
|         |              normal
|         |                  |
|   50    |                VC| Data format (ASCII)
| 51 - 53 |         20  3 87 | Production date:      20-Mar-87
| 54 - 56 |         20  3 87 | Date of last change: 20-Mar-87
|---------|------------------|----------------------------------------------------
|      FONT INFORMATION
|      ----------------
|   57    |                19| Length of font information
|   58    |                 1| Indicator for font
|   59    |               135| Number of characters
|   60    |               267| Cap height (in pixels)
|   61    |               400| Body size (in pixels)
|   62    |               187| x-height (in pixels)
|   63    |               100| Distance: base line - lower body line(in pixels)
|   64    |               400| Text line distance for setting (in pixels)
|   65    |                40| Stem thickness (in pixels)
|   66    |                 0| Angle of italisation (in 1/10 degree)
|   67    |                12| Optimum point size for setting (in p)
|   68    |               174| Average character width (in pixels)
|   69    |               375| X-extension of a pixel (in 1/1000mm)
|   70    |               375| Y-extension of a pixel (in 1/1000mm)
|   71    |               400| Em-resolution in X-direction (in pixels)
|   72    |               400| Em-resolution in Y-direction (in pixels)
|   73    |                21| Scan indicator of image data
|   74    |               400| Width of printing window (in pixels)
|   75    |               400| Height of printing window (in pixels)
|---------|------------------|----------------------------------------------------
|      HIERARCHY SECTION
|      -----------------
|   76    |                 1| No hierarchy section in this format
|---------|------------------|----------------------------------------------------
|        CHARACTER INDEX
|        ---------------
|   77    |               408| Length of character index
|   78    |                 9| LENGTH OF FONT IN PHYSICAL RECORDS
|   79    |               379| Last word of last record
|
|   80    |               101| Character number:  1
|   81    |                 1| Pointer to record containing start of character
|   82    |               485| Word pointer to start of character
|
|   83    |               102| Ch. no.: 2
|   84    |                 1| Record pointer
|   85    |               588| Word pointer
|
|  86-  88|   103      1  759| No., record pointer, word pointer of ch.:      3
|  89-  91|   104      1  884| No., record pointer, word pointer of ch.:      4
|  92-  94|   105      1 1011| No., record pointer, word pointer of ch.:      5
|---------|------------------|----------------------------------------------------
```

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AN201512.VC                        20-MAR-87                    PAGE    3

|---------|-------------------|-------------------------------------------------|
| WORDNO. |      CONTENT      |                     COMMENT                     |
|---------|-------------------|-------------------------------------------------|
| 272- 274|   331      5 1116 | No., record pointer, word pointer of ch.:   65  |
| 275- 277|   401      5 1185 | No., record pointer, word pointer of ch.:   66  |
| 278- 280|   408      5 1434 | No., record pointer, word pointer of ch.:   67  |
| 281- 283|   413      5 1699 | No., record pointer, word pointer of ch.:   68  |
| 284- 286|   436      5 1875 | No., record pointer, word pointer of ch.:   69  |
| 287- 289|   449      6   21 | No., record pointer, word pointer of ch.:   70  |
| 290- 292|   501      6  200 | No., record pointer, word pointer of ch.:   71  |
| 293- 295|   502      6  281 | No., record pointer, word pointer of ch.:   72  |
| 296- 298|   503      6  418 | No., record pointer, word pointer of ch.:   73  |
| 299- 301|   504      6  552 | No., record pointer, word pointer of ch.:   74  |
| 302- 304|   505      6  618 | No., record pointer, word pointer of ch.:   75  |
| 305- 307|   506      6  768 | No., record pointer, word pointer of ch.:   76  |
| 308- 310|   507      6  940 | No., record pointer, word pointer of ch.:   77  |
| 311- 313|   508      6 1017 | No., record pointer, word pointer of ch.:   78  |
| 314- 316|   509      6 1218 | No., record pointer, word pointer of ch.:   79  |
| 317- 319|   510      6 1395 | No., record pointer, word pointer of ch.:   80  |
| 320- 322|   511      6 1522 | No., record pointer, word pointer of ch.:   81  |
| 323- 325|   512      6 1752 | No., record pointer, word pointer of ch.:   82  |
| 326- 328|   513      6 1975 | No., record pointer, word pointer of ch.:   83  |
| 329- 331|   601      7   80 | No., record pointer, word pointer of ch.:   84  |
| 332- 334|   602      7  122 | No., record pointer, word pointer of ch.:   85  |
| 335- 337|   603      7  185 | No., record pointer, word pointer of ch.:   86  |
| 338- 340|   604      7  227 | No., record pointer, word pointer of ch.:   87  |
| 341- 343|   605      7  269 | No., record pointer, word pointer of ch.:   88  |
| 344- 346|   606      7  311 | No., record pointer, word pointer of ch.:   89  |
| 347- 349|   607      7  395 | No., record pointer, word pointer of ch.:   90  |
| 350- 352|   608      7  470 | No., record pointer, word pointer of ch.:   91  |
| 353- 355|   609      7  566 | No., record pointer, word pointer of ch.:   92  |
| 356- 358|   610      7  641 | No., record pointer, word pointer of ch.:   93  |
| 359- 361|   611      7  716 | No., record pointer, word pointer of ch.:   94  |
| 362- 364|   612      7  845 | No., record pointer, word pointer of ch.:   95  |
| 365- 367|   613      7  974 | No., record pointer, word pointer of ch.:   96  |
| 368- 370|   614      7 1103 | No., record pointer, word pointer of ch.:   97  |
| 371- 373|   615      7 1206 | No., record pointer, word pointer of ch.:   98  |
| 374- 376|   616      7 1309 | No., record pointer, word pointer of ch.:   99  |
| 377- 379|   617      7 1448 | No., record pointer, word pointer of ch.:  100  |
| 380- 382|   618      7 1587 | No., record pointer, word pointer of ch.:  101  |
| 383- 385|   619      7 1638 | No., record pointer, word pointer of ch.:  102  |
| 386- 388|   620      7 1689 | No., record pointer, word pointer of ch.:  103  |
```

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|---------|-------------------|-------------------------------------------------|
| WORDNO. |      CONTENT      |                     COMMENT                     |
|---------|-------------------|-------------------------------------------------|
| 449- 451|   704      8 1662 | No., record pointer, word pointer of ch.:  124  |
| 452- 454|   705      8 1709 | No., record pointer, word pointer of ch.:  125  |
| 455- 457|   706      8 1756 | No., record pointer, word pointer of ch.:  126  |
| 458- 460|   709      8 1792 | No., record pointer, word pointer of ch.:  127  |
| 461- 463|   711      8 1879 | No., record pointer, word pointer of ch.:  128  |
| 464- 466|   751      8 1950 | No., record pointer, word pointer of ch.:  129  |
| 467- 469|   753      8 2037 | No., record pointer, word pointer of ch.:  130  |
| 470- 472|   754      9   92 | No., record pointer, word pointer of ch.:  131  |
| 473- 475|   755      9  139 | No., record pointer, word pointer of ch.:  132  |
| 476- 478|   756      9  186 | No., record pointer, word pointer of ch.:  133  |
| 479- 481|   759      9  222 | No., record pointer, word pointer of ch.:  134  |
| 482- 484|   761      9  309 | No., record pointer, word pointer of ch.:  135  |
|         |                   |                                                 |
|---------|-------------------|-------------------------------------------------|
AN201512.VC                    20-MAR-87                    PAGE    5

|---------|------------------|---------------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                        |
|---------|------------------|---------------------------------------------------|
|    1    |                0 | Records     length of character                    |
|    2    |              183 | Words                                             |
|---------|------------------|---------------------------------------------------|
      NAME SECTION
      ------------
     3    |                3 | Length of name section
     4    |              301 | Character number
     5    |                0 | Number of following part
 ---------|------------------|---------------------------------------------------
      SETTING INFORMATION
      -------------------
     6    |               12 | Length of setting information
     7    |                1 | Character type = letter
     8    |              136 | Number of vectors
     9    |              206 | Total set width (T=L+W+R)
    10    |               15 | Left side bearing (L)
    11    |              194 | Width (W)
    12    |               -3 | Right side bearing (R)
    13    |                0 | X-minimum
    14    |              194 | X-maximum
    15    |               -4 | Y-minimum
    16    |              191 | Y-maximum
    17    |                1 | Unit is 1 pixel
 ---------|------------------|---------------------------------------------------
      CONTOUR INDEX
      -------------
    18    |                0 | Records     length of contour index
    19    |               14 | Words

    20    |                0 | Record pointer for   1. contour:      0
    21    |                3 | Word pointer                    :     34
    22    |               -1 | Sense of rotation of contour = clockwise
    23    |                0 | Nesting: outer  1. order
    24    |                0 | Colour inside: transparent
    25    |              108 | Number of digitizations

    26    |                0 | Record pointer for   2. contour:      0
    27    |              121 | Word pointer                    :    152
    28    |               -1 | Sense of rotation of contour = clockwise
    29    |                1 | Nesting: inner  1. order
    30    |                0 | Colour inside: transparent
    31    |               28 | Number of digitizations

 ---------|------------------|---------------------------------------------------
      IMAGE INFORMATION
      -----------------
    32    |                0 | Records     length of image information
    33    |              152 | Words

  34 -151 |     192       28 |       192     28   (dX,dY)         1.DIG w-vector
   36 1   | 7E   02   F9     |  126    2   -7   (K,dX,dY)         2.DIG s-vector
   37 2   |      FA   F9     |        -6   -7     (dX,dY)         3.DIG s-vector
   38 2   |      FC   FD     |        -4   -3     (dX,dY)         4.DIG s-vector
   39 2   |      F9   FB     |        -7   -5     (dX,dY)         5.DIG s-vector
   40 2   |      F8   FC     |        -8   -4     (dX,dY)         6.DIG s-vector
   41 2   |      F6   FD     |       -10   -3     (dX,dY)         7.DIG s-vector
   42 2   |      F9   FE     |        -7   -2     (dX,dY)         8.DIG s-vector
   43 2   |      FA   01     |        -6    1     (dX,dY)         9.DIG s-vector
|---------|------------------|---------------------------------------------------|
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---------  ------------------------  --------------------------------------------------------
 WORDNO.           CONTENT                                 COMMENT
---------  ------------------------  --------------------------------------------------------
   44 2          F9    02                -7    2        (dX,dY)      10.DIG s-vector
   45 2          FA    04                -6    4        (dX,dY)      11.DIG s-vector
   46 2          FB    05                -5    5        (dX,dY)      12.DIG s-vector
   47 2          FD    06                -3    6        (dX,dY)      13.DIG s-vector
   48 2          FD    06                -3    6        (dX,dY)      14.DIG s-vector
   49 2          FE    07                -2    7        (dX,dY)      15.DIG s-vector
   50 2          FE    00                -2    0        (dX,dY)      16.DIG s-vector
   51 2          FA    FA                -6   -6        (dX,dY)      17.DIG s-vector
   52 2          FD    FC                -3   -4        (dX,dY)      18.DIG s-vector
   53 2          F8    FA                -8   -6        (dX,dY)      19.DIG s-vector
   54 2          F8    FB                -8   -5        (dX,dY)      20.DIG s-vector
   55 2          F6    FB               -10   -5        (dX,dY)      21.DIG s-vector
   56 2          F6    FC               -10   -4        (dX,dY)      22.DIG s-vector
   57 2          F7    FF                -9   -1        (dX,dY)      23.DIG s-vector
   58 2          F7    FF                -9   -1        (dX,dY)      24.DIG s-vector
   59 2    7D    F1    02    FE    125  -15    2   -2 (K,dX,dY,dS)   25.DIG c-vector
   61 2          F2    04    FE         -14    4   -2   (dX,dY,dS)   26.DIG c-vector
   63 1          F4    0A    FD         -12   10   -3   (dX,dY,dS)   27.DIG c-vector
   64 2          F7    0C    FD          -9   12   -3   (dX,dY,dS)   28.DIG c-vector
   66 1          FC    0D    FE          -4   13   -2   (dX,dY,dS)   29.DIG c-vector
   67 2          FF    0E    FE          -1   14   -2   (dX,dY,dS)   30.DIG c-vector
   69 1    7E    01    0B          126    1   11      (K,dX,dY)      31.DIG s-vector
   70 2          03    09                 3    9        (dX,dY)      32.DIG s-vector
   71 2          04    09                 4    9        (dX,dY)      33.DIG s-vector
   72 2          06    07                 6    7        (dX,dY)      34.DIG s-vector
   73 2    7D    0C    08    FE    125   12    8   -2 (K,dX,dY,dS)   35.DIG c-vector
   75 2          0F    06    FE           15    6   -2   (dX,dY,dS)   36.DIG c-vector
   77 1    7E    0C    03          126   12    3      (K,dX,dY)      37.DIG s-vector
   78 2          0E    03                14    3        (dX,dY)      38.DIG s-vector
   79 2          0F    02                15    2        (dX,dY)      39.DIG s-vector
   80 2          23    06                35    6        (dX,dY)      40.DIG s-vector
   81 2          03    05                 3    5        (dX,dY)      41.DIG s-vector
   82 2          00    08                 0    8        (dX,dY)      42.DIG s-vector
   83 2          FF    04                -1    4        (dX,dY)      43.DIG s-vector
   84 2          00    07                 0    7        (dX,dY)      44.DIG s-vector
   85 2          FE    08                -2    8        (dX,dY)      45.DIG s-vector
   86 2          FB    0C                -5   12        (dX,dY)      46.DIG s-vector
   87 2          FB    08                -5    8        (dX,dY)      47.DIG s-vector
   88 2          FA    05                -6    5        (dX,dY)      48.DIG s-vector
   89 2          F7    05                -9    5        (dX,dY)      49.DIG s-vector
   90 2          F8    01                -8    1        (dX,dY)      50.DIG s-vector
   91 2          F8    01                -8    1        (dX,dY)      51.DIG s-vector
   92 2          FA    FF                -6   -1        (dX,dY)      52.DIG s-vector
   93 2          FB    FF                -5   -1        (dX,dY)      53.DIG s-vector
   94 2          FC    FF                -4   -1        (dX,dY)      54.DIG s-vector
   95 2          FD    FE                -3   -2        (dX,dY)      55.DIG s-vector
   96 2          FE    FF                -2   -1        (dX,dY)      56.DIG s-vector
   97 2          FF    FF                -1   -1        (dX,dY)      57.DIG s-vector
   98 2          FE    FE                -2   -2        (dX,dY)      58.DIG s-vector
   99 2          FF    FF                -1   -1        (dX,dY)      59.DIG s-vector
  100 2          01    FF                 1   -1        (dX,dY)      60.DIG s-vector
  101 2          01    FE                 1   -2        (dX,dY)      61.DIG s-vector
  102 2          03    FC                 3   -4        (dX,dY)      62.DIG s-vector
  103 2          03    FE                 3   -2        (dX,dY)      63.DIG s-vector
  104 2          01    FC                 1   -4        (dX,dY)      64.DIG s-vector
  105 2          01    FD                 1   -3        (dX,dY)      65.DIG s-vector
  106 2          01    FC                 1   -4        (dX,dY)      66.DIG s-vector
  107 2          FF    FA                -1   -6        (dX,dY)      67.DIG s-vector
  108 2          FE    FB                -2   -5        (dX,dY)      68.DIG s-vector
---------  ------------------------  --------------------------------------------------------
```

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|---------|------------------|--------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|  109 2  |      FC   FB     |       -4  -5        (dX,dY)        69.DIG s-vector|
|  110 2  |      FB   FD     |       -5  -3        (dX,dY)        70.DIG s-vector|
|  111 2  |      FB   FE     |       -5  -2        (dX,dY)        71.DIG s-vector|
|  112 2  |      F9   FF     |       -7  -1        (dX,dY)        72.DIG s-vector|
|  113 2  |      FB   00     |       -5   0        (dX,dY)        73.DIG s-vector|
|  114 2  |      FC   02     |       -4   2        (dX,dY)        74.DIG s-vector|
|  115 2  |      FA   04     |       -6   4        (dX,dY)        75.DIG s-vector|
|  116 2  |      FC   07     |       -4   7        (dX,dY)        76.DIG s-vector|
|  117 2  |      FE   05     |       -2   5        (dX,dY)        77.DIG s-vector|
|  118 2  |      FF   07     |       -1   7        (dX,dY)        78.DIG s-vector|
|  119 2  |      01   05     |        1   5        (dX,dY)        79.DIG s-vector|
|  120 2  |      02   05     |        2   5        (dX,dY)        80.DIG s-vector|
|  121 2  |      05   08     |        5   8        (dX,dY)        81.DIG s-vector|
|  122 2  |      05   06     |        5   6        (dX,dY)        82.DIG s-vector|
|  123 2  |      0B   07     |       11   7        (dX,dY)        83.DIG s-vector|
|  124 2  |      0C   04     |       12   4        (dX,dY)        84.DIG s-vector|
|  125 2  |      0D   02     |       13   2        (dX,dY)        85.DIG s-vector|
|  126 2  |      0E   02     |       14   2        (dX,dY)        86.DIG s-vector|
|  127 2  |      11   FF     |       17  -1        (dX,dY)        87.DIG s-vector|
|  128 2  |      0F   FE     |       15  -2        (dX,dY)        88.DIG s-vector|
|  129 2  |      0D   FC     |       13  -4        (dX,dY)        89.DIG s-vector|
|  130 2  |      0A   FA     |       10  -6        (dX,dY)        90.DIG s-vector|
|  131 2  |  7D  09   F6  FE | 125    9 -10   -2 (K,dX,dY,dS)     91.DIG c-vector|
|  133 2  |      06   F4  FE |        6 -12   -2   (dX,dY,dS)     92.DIG c-vector|
|  135 1  |  7E  04   F4     | 126    4 -12       (K,dX,dY)       93.DIG s-vector|
|  136 2  |      01   F5     |        1 -11        (dX,dY)        94.DIG s-vector|
|  137 2  |      00   F3     |        0 -13        (dX,dY)        95.DIG s-vector|
|  138 2  |      00   C5     |        0 -59        (dX,dY)        96.DIG s-vector|
|  139 2  |      00   F5     |        0 -11        (dX,dY)        97.DIG s-vector|
|  140 2  |      01   F8     |        1  -8        (dX,dY)        98.DIG s-vector|
|  141 2  |      00   FB     |        0  -5        (dX,dY)        99.DIG s-vector|
|  142 2  |      03   F8     |        3  -8        (dX,dY)       100.DIG s-vector|
|  143 2  |      05   FC     |        5  -4        (dX,dY)       101.DIG s-vector|
|  144 2  |      04   FD     |        4  -3        (dX,dY)       102.DIG s-vector|
|  145 2  |      05   00     |        5   0        (dX,dY)       103.DIG s-vector|
|  146 2  |      04   00     |        4   0        (dX,dY)       104.DIG s-vector|
|  147 2  |      04   01     |        4   1        (dX,dY)       105.DIG s-vector|
|  148 2  |      04   01     |        4   1        (dX,dY)       106.DIG s-vector|
|  149 2  |      03   02     |        3   2        (dX,dY)       107.DIG s-vector|
|  150 2  |      04   02     |        4   2        (dX,dY)       108.DIG s-vector|
| 152 -183|       -72     73 |       -72     73    (dX,dY)       109.DIG w-vector|
|  154 1  |  7E  00   E3     | 126    0 -29       (K,dX,dY)      110.DIG s-vector|
|  155 2  |      00   FB     |        0  -5        (dX,dY)       111.DIG s-vector|
|  156 2  |      00   FA     |        0  -6        (dX,dY)       112.DIG s-vector|
|  157 2  |      FE   F6     |       -2 -10        (dX,dY)       113.DIG s-vector|
|  158 2  |      FE   FA     |       -2  -6        (dX,dY)       114.DIG s-vector|
|  159 2  |      FD   FA     |       -3  -6        (dX,dY)       115.DIG s-vector|
|  160 2  |      FB   FA     |       -5  -6        (dX,dY)       116.DIG s-vector|
|  161 2  |      F9   FA     |       -7  -6        (dX,dY)       117.DIG s-vector|
|  162 2  |      F7   FB     |       -9  -5        (dX,dY)       118.DIG s-vector|
|  163 2  |      F7   FD     |       -9  -3        (dX,dY)       119.DIG s-vector|
|  164 2  |      F5   FF     |      -11  -1        (dX,dY)       120.DIG s-vector|
|  165 2  |      F6   01     |      -10   1        (dX,dY)       121.DIG s-vector|
|  166 2  |      F7   04     |       -9   4        (dX,dY)       122.DIG s-vector|
|  167 2  |      F9   07     |       -7   7        (dX,dY)       123.DIG s-vector|
|  168 2  |      FB   07     |       -5   7        (dX,dY)       124.DIG s-vector|
|  169 2  |      FD   09     |       -3   9        (dX,dY)       125.DIG s-vector|
|  170 2  |      FF   0A     |       -1  10        (dX,dY)       126.DIG s-vector|
|  171 2  |      01   0A     |        1  10        (dX,dY)       127.DIG s-vector|
|---------|------------------|--------------------------------------------------|
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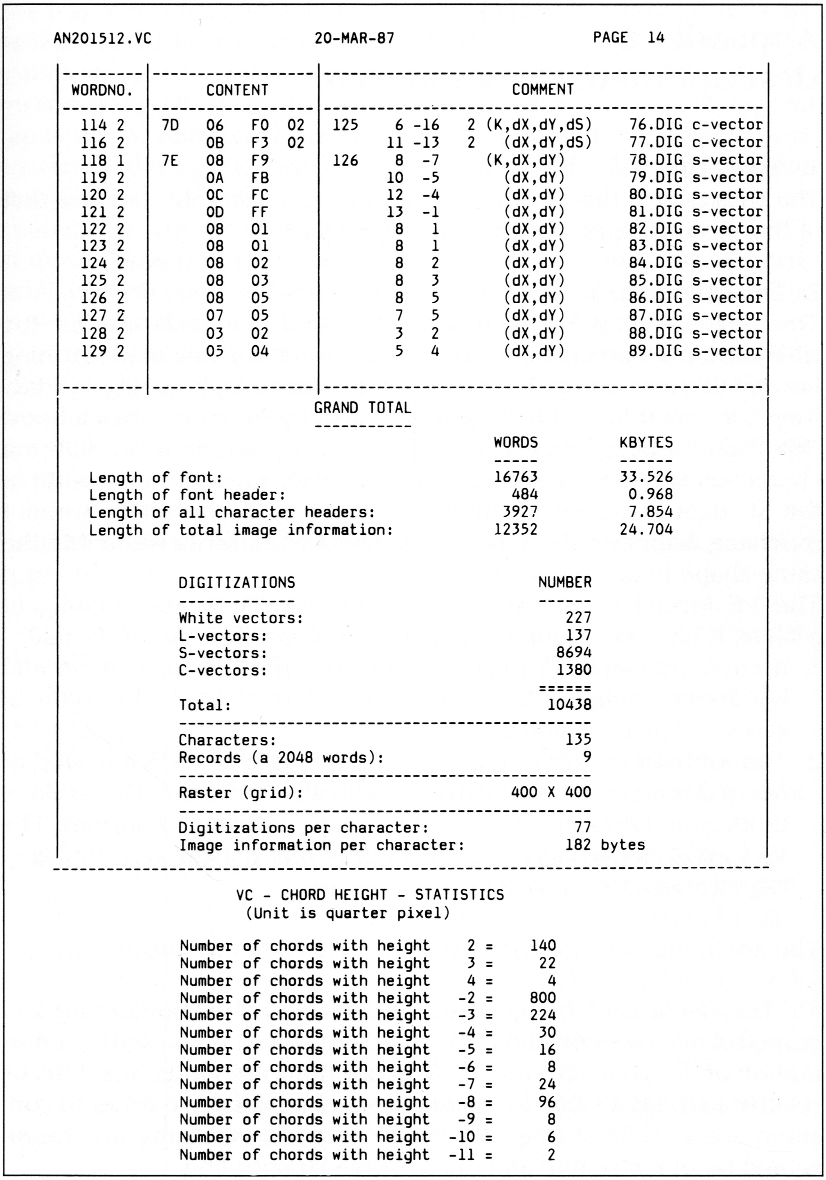
|---------- |------------------ |--------------------------------------------------|
| WORDNO.   |      CONTENT      |                     COMMENT                      |
|---------- |------------------ |--------------------------------------------------|
|     1     |                0  | Records      length of character                 |
|     2     |              147  | Words                                            |
|---------- |------------------ |--------------------------------------------------|
|      NAME SECTION                                                                |
|      ------------                                                                |
|     3     |                3  | Length of name section                           |
|     4     |              302  | Character number                                 |
|     5     |                0  | Number of following part                         |
|---------- |------------------ |--------------------------------------------------|
|      SETTING INFORMATION                                                         |
|      -------------------                                                         |
|     6     |               12  | Length of setting information                    |
|     7     |                1  | Character type = letter                          |
|     8     |               89  | Number of vectors                                |
|     9     |              257  | Total set width (T=L+W+R)                        |
|    10     |                0  | Left side bearing (L)                            |
|    11     |              237  | Width (W)                                        |
|    12     |               20  | Right side bearing (R)                           |
|    13     |                0  | X-minimum                                        |
|    14     |              237  | X-maximum                                        |
|    15     |               -5  | Y-minimum                                        |
|    16     |              280  | Y-maximum                                        |
|    17     |                1  | Unit is 1 pixel                                  |
|---------- |------------------ |--------------------------------------------------|
|      CONTOUR INDEX                                                               |
|      -------------                                                               |
|    18     |                0  | Records     length of contour index              |
|    19     |               14  | Words                                            |
|           |                   |                                                  |
|    20     |                0  | Record pointer for   1. contour:      0          |
|    21     |                3  | Word pointer                     :    34         |
|    22     |               -1  | Sense of rotation of contour = clockwise         |
|    23     |                0  | Nesting: outer  1. order                         |
|    24     |                0  | Colour inside: transparent                       |
|    25     |               56  | Number of digitizations                          |
|           |                   |                                                  |
|    26     |                0  | Record pointer for   2. contour:      0          |
|    27     |               71  | Word pointer                     :   102         |
|    28     |               -1  | Sense of rotation of contour = clockwise         |
|    29     |                1  | Nesting: inner  1. order                         |
|    30     |                0  | Colour inside: transparent                       |
|    31     |               33  | Number of digitizations                          |
|           |                   |                                                  |
|---------- |------------------ |--------------------------------------------------|
|      IMAGE INFORMATION                                                           |
|      -----------------                                                           |
|    32     |                0  | Records     length of image information          |
|    33     |              116  | Words                                            |
|                                                                                  |
|   34 -101       53       -5          53    -5   (dX,dY)          1.DIG w-vector |
|    36 1  | 7E   F6    00     | 126  -10    0     (K,dX,dY)         2.DIG s-vector |
|    37 2  | 7F      0    218  | 127     0   218 (K,dX,dY)           3.DIG l-vector |
|    40 1  | 7E   00    09     | 126     0   9     (K,dX,dY)         4.DIG s-vector |
|    41 2  |      00    08     |         0   8       (dX,dY)         5.DIG s-vector |
|    42 2  |      FF    06     |        -1   6       (dX,dY)         6.DIG s-vector |
|    43 2  |      FD    07     |        -3   7       (dX,dY)         7.DIG s-vector |
|    44 2  |      FD    04     |        -3   4       (dX,dY)         8.DIG s-vector |
|    45 2  |      FC    03     |        -4   3       (dX,dY)         9.DIG s-vector |
|---------- |------------------ |--------------------------------------------------|
AN201512.VC                    20-MAR-87                   PAGE  12

|---------|------------------|-------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                     |
|---------|------------------|-------------------------------------------------|
     1    |                0 | Records      length of character
     2    |              130 | Words
|---------|------------------|-------------------------------------------------|
      NAME SECTION
      ------------
     3    |                3 | Length of name section
     4    |              303 | Character number
     5    |                0 | Number of following part
|---------|------------------|-------------------------------------------------|
      SETTING INFORMATION
      -------------------
     6    |               12 | Length of setting information
     7    |                1 | Character type = letter
     8    |               89 | Number of vectors
     9    |              198 | Total set width (T=L+W+R)
    10    |               20 | Left side bearing (L)
    11    |              167 | Width (W)
    12    |               11 | Right side bearing (R)
    13    |                0 | X-minimum
    14    |              167 | X-maximum
    15    |               -4 | Y-minimum
    16    |              191 | Y-maximum
    17    |                1 | Unit is 1 pixel
|---------|------------------|-------------------------------------------------|
      CONTOUR INDEX
      -------------
    18    |                0 | Records     length of contour index
    19    |                8 | Words
          |                  |
    20    |                0 | Record pointer for   1. contour:     0
    21    |                3 | Word pointer                    :    28
    22    |               -1 | Sense of rotation of contour = clockwise
    23    |                0 | Nesting: outer  1. order
    24    |                0 | Colour inside: transparent
    25    |               89 | Number of digitizations
          |                  |
|---------|------------------|-------------------------------------------------|
      IMAGE INFORMATION
      -----------------
    26    |                0 | Records     length of image information
    27    |              105 | Words
          |                  |
   28 -130|      160     38  |         160    38   (dX,dY)          1.DIG w-vector
    30 1  |  7E   05    F8   |  126     5   -8     (K,dX,dY)        2.DIG s-vector
    31 2  |       FA    FA   |         -6   -6       (dX,dY)        3.DIG s-vector
    32 2  |       FD    FD   |         -3   -3       (dX,dY)        4.DIG s-vector
    33 2  |       F7    F9   |         -9   -7       (dX,dY)        5.DIG s-vector
    34 2  |       F6    FA   |        -10   -6       (dX,dY)        6.DIG s-vector
    35 2  |       F5    FB   |        -11   -5       (dX,dY)        7.DIG s-vector
    36 2  |       F4    FC   |        -12   -4       (dX,dY)        8.DIG s-vector
    37 2  |       F2    FE   |        -14   -2       (dX,dY)        9.DIG s-vector
    38 2  |       F4    FF   |        -12   -1       (dX,dY)       10.DIG s-vector
    39 2  |       EF    01   |        -17    1       (dX,dY)       11.DIG s-vector
    40 2  |       F1    04   |        -15    4       (dX,dY)       12.DIG s-vector
    41 2  |  7D   F2    08  FE  125  -14    8  -2 (K,dX,dY,dS)     13.DIG c-vector
    43 2  |       F3    0A  FE       -13   10  -2   (dX,dY,dS)     14.DIG c-vector
    45 1  |       F4    0F  FE       -12   15  -2   (dX,dY,dS)     15.DIG c-vector
    46 2  |       F6    12  FE       -10   18  -2   (dX,dY,dS)     16.DIG c-vector
|---------|------------------|-------------------------------------------------|
```



```
AN201512.VC                    20-MAR-87                    PAGE  14

|---------|------------------|--------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|  114 2  | 7D   06   F0  02 | 125     6 -16   2 (K,dX,dY,dS)     76.DIG c-vector|
|  116 2  |      0B   F3  02 |        11 -13   2   (dX,dY,dS)     77.DIG c-vector|
|  118 1  | 7E   08   F9     | 126     8  -7     (K,dX,dY)        78.DIG s-vector|
|  119 2  |      0A   FB     |        10  -5       (dX,dY)        79.DIG s-vector|
|  120 2  |      0C   FC     |        12  -4       (dX,dY)        80.DIG s-vector|
|  121 2  |      0D   FF     |        13  -1       (dX,dY)        81.DIG s-vector|
|  122 2  |      08   01     |         8   1       (dX,dY)        82.DIG s-vector|
|  123 2  |      08   01     |         8   1       (dX,dY)        83.DIG s-vector|
|  124 2  |      08   02     |         8   2       (dX,dY)        84.DIG s-vector|
|  125 2  |      08   03     |         8   3       (dX,dY)        85.DIG s-vector|
|  126 2  |      08   05     |         8   5       (dX,dY)        86.DIG s-vector|
|  127 2  |      07   05     |         7   5       (dX,dY)        87.DIG s-vector|
|  128 2  |      03   02     |         3   2       (dX,dY)        88.DIG s-vector|
|  129 2  |      05   04     |         5   4       (dX,dY)        89.DIG s-vector|
|         |                  |                                                  |
|---------|------------------|--------------------------------------------------|
|                            GRAND TOTAL                                         |
|                            -----------                                         |
|                                                WORDS        KBYTES             |
|                                                -----        ------             |
|   Length of font:                              16763        33.526             |
|   Length of font header:                         484         0.968             |
|   Length of all character headers:              3927         7.854             |
|   Length of total image information:           12352        24.704             |
|                                                                                |
|                                                                                |
|            DIGITIZATIONS                        NUMBER                         |
|            -------------                        ------                         |
|            White vectors:                          227                         |
|            L-vectors:                              137                         |
|            S-vectors:                             8694                         |
|            C-vectors:                             1380                         |
|                                                 ======                         |
|            Total:                                10438                         |
|            --------------------------------------------                        |
|            Characters:                             135                         |
|            Records (a 2048 words):                   9                         |
|            --------------------------------------------                        |
|            Raster (grid):                    400 X 400                         |
|            --------------------------------------------                        |
|            Digitizations per character:             77                         |
|            Image information per character:        182 bytes                   |
|                                                                                |
----------------------------------------------------------------------------------
                        VC - CHORD HEIGHT - STATISTICS
                         (Unit is quarter pixel)

             Number of chords with height   2 =    140
             Number of chords with height   3 =     22
             Number of chords with height   4 =      4
             Number of chords with height  -2 =    800
             Number of chords with height  -3 =    224
             Number of chords with height  -4 =     30
             Number of chords with height  -5 =     16
             Number of chords with height  -6 =      8
             Number of chords with height  -7 =     24
             Number of chords with height  -8 =     96
             Number of chords with height  -9 =      8
             Number of chords with height -10 =      6
             Number of chords with height -11 =      2
```

Appendix L
Description of the VS format

1. Structure of a VS font

The structure of the **vector scaling font** is exactly the same as that of the VC format, as described in appendix K.

2. Description of the VS format

The vector scaling format was created as a master format for the URW raster image processor (RIP), a software capable of performing fast, intelligent scaling. The URW RIP produces high quality SC data from VS format in a wide range of point sizes for various resolutions. "Intelligent scaling" especially means that similar stems in different characters of a given typeface will all have exactly the same width in the SC data. Also, for example, all upper case characters without overhang will have the same cap height, and all serifs will retain the same shape in all characters.

The VS format is an extended VC format. To enable intelligent scaling, it has two additional features, compared to the VC format:

1. It contains extra information about the position of vertical and horizontal straight lines (stem edges), curved stems, locations of serifs and peak positions.
2. The width of similar stems, cap height, length of serifs and similar quantities are set to the same value in all characters. This is done by using a two-step fit procedure when creating VS format. The VS format is normally created in only one master size, typically 720 × 720 or 1080 × 1080 for the em square.

The additional information is stored at two different locations:

a) The positions of straight lines (either vertical or horizontal) and curved stems (vertical and horizontal) are stored in the setting information of the character record. The positions are either absolute, or relative to the last value in the sequence of positions. In order to conserve stem width during the rastering process, stems are represented by one absolute and one relative straight line.

The features of the additional data items in the character headers are demonstrated in a simple character. Here, only vertical and horizontal straight lines are present, but the same holds true also for curved stems. By marking descender line, baseline, meanline, and cap height as horizontal straight lines, we ensure that the heights are preserved during RIP processing. By marking each stem with one absolute and one relative value we make sure that stem widths are treated correctly when scaled down to the (SC) target grid.
In most characters, only one set of stem edges (consisting of horizontal/vertical curve extrema) is needed, because they only have one contour with hierarchy level zero (outer contour 1st order). In some characters, though, there are more contours with hierarchy level one side by side (as in the case for percent or permille symbols) or on top of each other (i, j, characters with accents). In order to manipulate these different parts of the characters independently, the RIP needs a separate set of stems (stem block) for each of them.

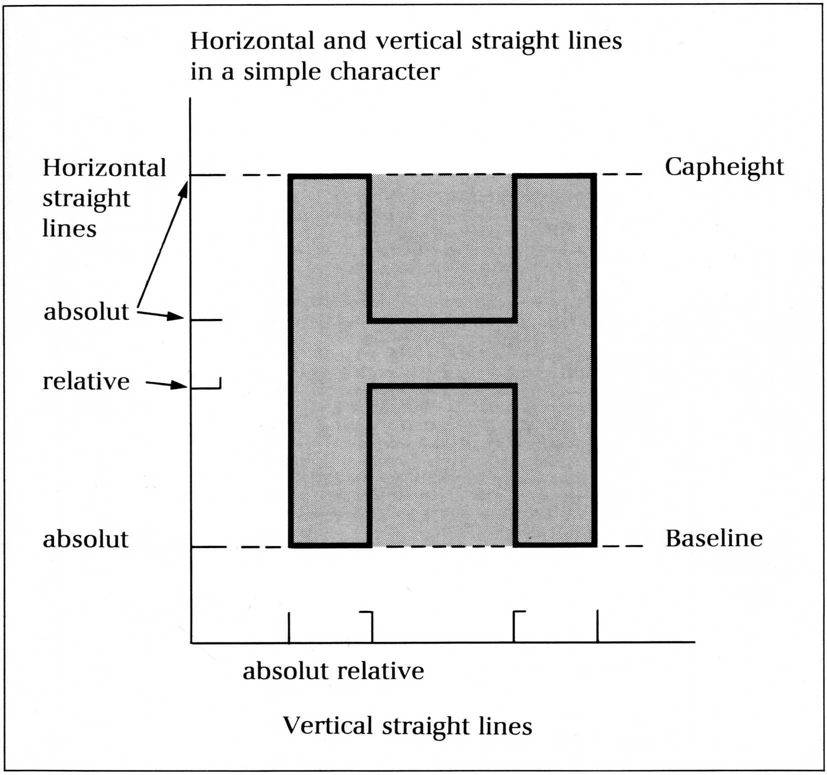
Format of stem block (extension of character record, see also appendix G)

Word	Meaning	Comment
N1 + N2		
+3	Number of K contours for which the first stem block applies.	K > 0 stem block applies to reset K contours. K < 0 stem block is empty, length of stem block is 1. For an i, for example, there are two stem blocks, each for one contour.
+4	Number of vertical straight lines	NV1 (may be = 0)

Word	Meaning	Comment
NV1 words	Positions of vertical straight lines	If value is >8192: absolute position $=$ value $-16{,}384$. In all other cases: relative position $=$ value.
$+NV1+5$	Number of vertical curve extrema	NV2 (may be = 0)
NV2 words	Positions of vertical curve extrema	Same as above
$+NV1+NV2$ $+6$	Number of horizontal straight lines	NV3 (may be = 0)
NV3 words	Positions of horizontal straight lines	Same as above
$+NV1+NV2$ $+NV3+7$	Number of horizontal curve extrema	NV4 (may be = 0)
NV4 words	Positions of horizontal curve extrema	Same as above
$+NV1+NV2$ $+NV3+NV4$ $+7$	Last data word in first stem block	
$+NV1+NV2$ $+NV3+NV4$ $+8$	Number of K contours for which the second stem block applies.	
.		
.	Second stem block	

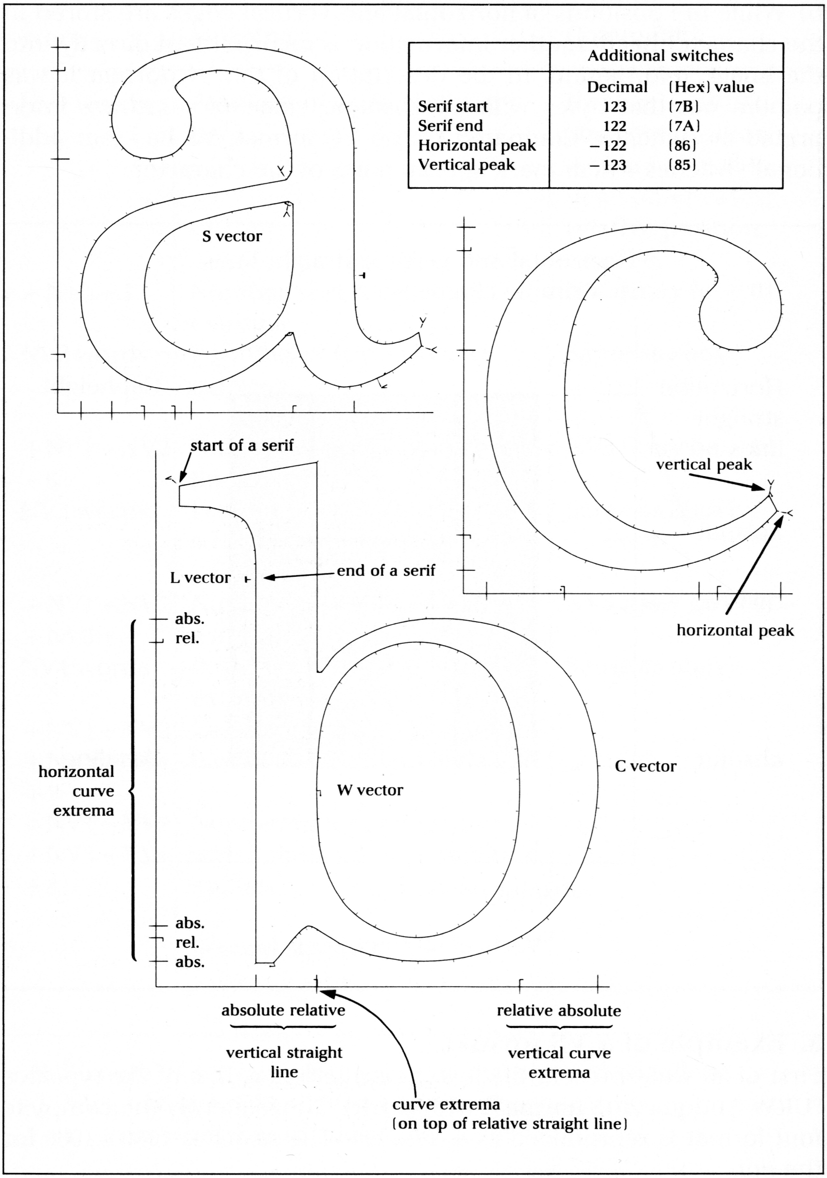
N2 (length of setting information) is therefore changed to:
$\sum(NV1_i+NV2_i+NV3_i+NV4_i)+5n$
$i=1, \ldots n$; $n=$ number of stem blocks

b) While the positions of horizontal and vertical edges are stored in the character header, other information is incorporated directly into the image information. In the description of the VC format it was pointed out that bytes with an absolute value of >120 are interpreted as switches. Compared to the VC format, VS has four additional switches which mark special parts of the character.


Horizontal and vertical straight lines in a simple character
Horizontal straight lines
absolut
relative
absolut
Capheight
Baseline
absolut relative
Vertical straight lines

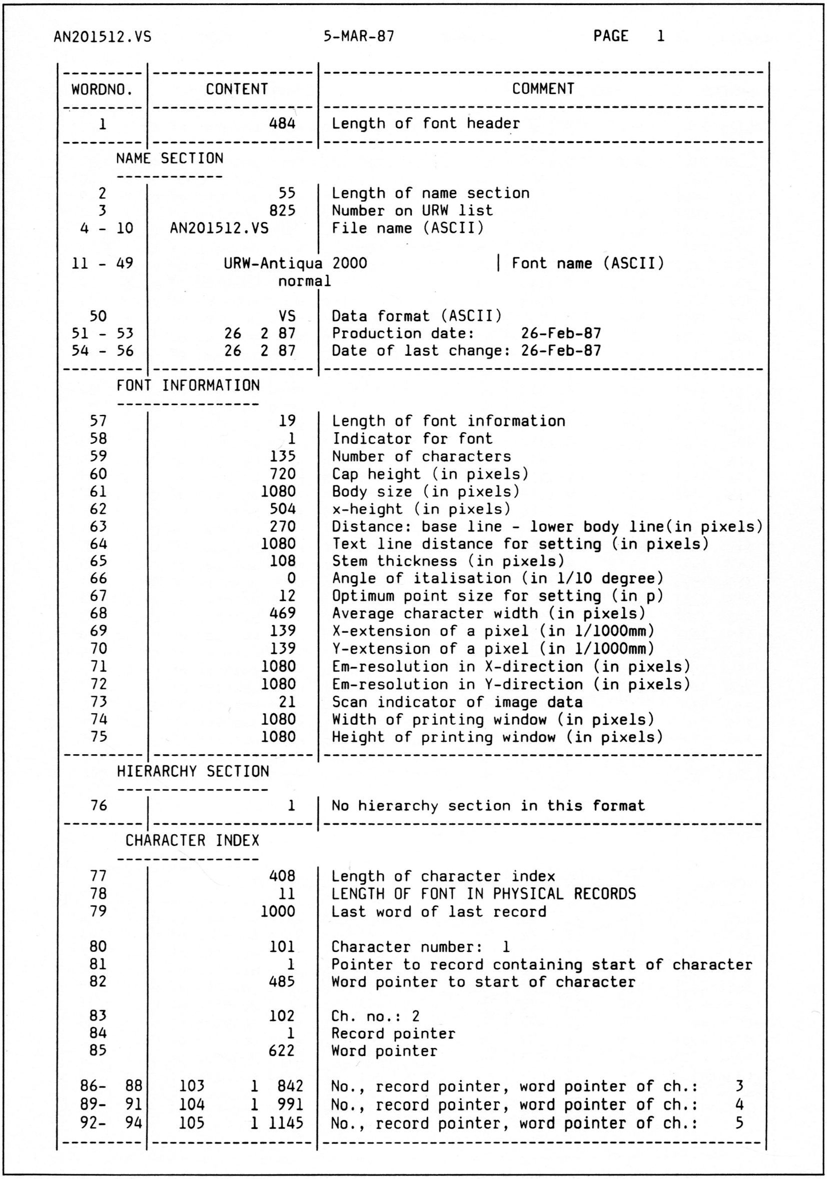
3. Example of a VS format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", with marks. Subsequently the complete font format is reproduced as a data list. The raster is 1080 × 1080 for the em.



	Additional switches	
	Decimal	(Hex) value
Serif start	123	(7B)
Serif end	122	(7A)
Horizontal peak	– 122	(86)
Vertical peak	– 123	(85)

S vector
start of a serif
L vector
end of a serif
abs.
rel.
horizontal curve extrema
W vector
C vector
abs.
rel.
abs.
absolute relative
vertical straight line
relative absolute
vertical curve extrema
curve extrema (on top of relative straight line)
vertical peak
horizontal peak



```
AN201512.VS                   5-MAR-87                      PAGE   1

|---------|------------------|-------------------------------------------------|
|WORDNO.  |      CONTENT     |                     COMMENT                     |
|---------|------------------|-------------------------------------------------|
|   1     |               484| Length of font header                           |
|---------|------------------|-------------------------------------------------|
       NAME SECTION
       ------------
    2    |                55 | Length of name section
    3    |               825 | Number on URW list
  4 - 10 |   AN201512.VS     | File name (ASCII)
         |                   |
 11 - 49 |        URW-Antiqua 2000              | Font name (ASCII)
         |              normal
         |                   |
   50    |                VS | Data format (ASCII)
 51 - 53 |          26  2 87 | Production date:      26-Feb-87
 54 - 56 |          26  2 87 | Date of last change: 26-Feb-87
---------|-------------------|-------------------------------------------------
       FONT INFORMATION
       ----------------
   57    |                19 | Length of font information
   58    |                 1 | Indicator for font
   59    |               135 | Number of characters
   60    |               720 | Cap height (in pixels)
   61    |              1080 | Body size (in pixels)
   62    |               504 | x-height (in pixels)
   63    |               270 | Distance: base line - lower body line(in pixels)
   64    |              1080 | Text line distance for setting (in pixels)
   65    |               108 | Stem thickness (in pixels)
   66    |                 0 | Angle of italisation (in 1/10 degree)
   67    |                12 | Optimum point size for setting (in p)
   68    |               469 | Average character width (in pixels)
   69    |               139 | X-extension of a pixel (in 1/1000mm)
   70    |               139 | Y-extension of a pixel (in 1/1000mm)
   71    |              1080 | Em-resolution in X-direction (in pixels)
   72    |              1080 | Em-resolution in Y-direction (in pixels)
   73    |                21 | Scan indicator of image data
   74    |              1080 | Width of printing window (in pixels)
   75    |              1080 | Height of printing window (in pixels)
---------|-------------------|-------------------------------------------------
       HIERARCHY SECTION
       -----------------
   76    |                 1 | No hierarchy section in this format
---------|-------------------|-------------------------------------------------
        CHARACTER INDEX
       ----------------
   77    |               408 | Length of character index
   78    |                11 | LENGTH OF FONT IN PHYSICAL RECORDS
   79    |              1000 | Last word of last record

   80                    101   Character number:  1
   81                      1   Pointer to record containing start of character
   82                    485   Word pointer to start of character

   83                    102   Ch. no.: 2
   84                      1   Record pointer
   85                    622   Word pointer

  86- 88 |   103     1  842  | No., record pointer, word pointer of ch.:     3
  89- 91 |   104     1  991  | No., record pointer, word pointer of ch.:     4
  92- 94 |   105     1 1145  | No., record pointer, word pointer of ch.:     5
|---------|------------------|-------------------------------------------------|
AN201512.VS                    5-MAR-87                    PAGE   3

 ---------  ------------------  ---------------------------------------------
 WORDNO.         CONTENT                           COMMENT
 ---------  ------------------  ---------------------------------------------
 272- 274    331      6 1547     No., record pointer, word pointer of ch.:   65
 275- 277    401      6 1640     No., record pointer, word pointer of ch.:   66
 278- 280    408      6 1976     No., record pointer, word pointer of ch.:   67
 281- 283    413      7  287     No., record pointer, word pointer of ch.:   68
 284- 286    436      7  503     No., record pointer, word pointer of ch.:   69
 287- 289    449      7  747     No., record pointer, word pointer of ch.:   70
 290- 292    501      7  997     No., record pointer, word pointer of ch.:   71
 293- 295    502      7 1095     No., record pointer, word pointer of ch.:   72
 296- 298    503      7 1286     No., record pointer, word pointer of ch.:   73
 299- 301    504      7 1464     No., record pointer, word pointer of ch.:   74
 302- 304    505      7 1548     No., record pointer, word pointer of ch.:   75
 305- 307    506      7 1755     No., record pointer, word pointer of ch.:   76
 308- 310    507      7 1975     No., record pointer, word pointer of ch.:   77
 311- 313    508      8   32     No., record pointer, word pointer of ch.:   78
 314- 316    509      8  287     No., record pointer, word pointer of ch.:   79
 317- 319    510      8  513     No., record pointer, word pointer of ch.:   80
 320- 322    511      8  660     No., record pointer, word pointer of ch.:   81
 323- 325    512      8  990     No., record pointer, word pointer of ch.:   82
 326- 328    513      8 1292     No., record pointer, word pointer of ch.:   83
 329- 331    601      8 1483     No., record pointer, word pointer of ch.:   84
 332- 334    602      8 1533     No., record pointer, word pointer of ch.:   85
 335- 337    603      8 1608     No., record pointer, word pointer of ch.:   86
 338- 340    604      8 1658     No., record pointer, word pointer of ch.:   87
 341- 343    605      8 1708     No., record pointer, word pointer of ch.:   88
 344- 346    606      8 1758     No., record pointer, word pointer of ch.:   89
 347- 349    607      8 1858     No., record pointer, word pointer of ch.:   90
 350- 352    608      8 1953     No., record pointer, word pointer of ch.:   91
 353- 355    609      9   25     No., record pointer, word pointer of ch.:   92
 356- 358    610      9  120     No., record pointer, word pointer of ch.:   93
 359- 361    611      9  215     No., record pointer, word pointer of ch.:   94
 362- 364    612      9  380     No., record pointer, word pointer of ch.:   95
 365- 367    613      9  545     No., record pointer, word pointer of ch.:   96
 368- 370    614      9  710     No., record pointer, word pointer of ch.:   97
 371- 373    615      9  828     No., record pointer, word pointer of ch.:   98
 374- 376    616      9  947     No., record pointer, word pointer of ch.:   99
 377- 379    617      9 1134     No., record pointer, word pointer of ch.:  100
 380- 382    618      9 1321     No., record pointer, word pointer of ch.:  101
 383- 385    619      9 1388     No., record pointer, word pointer of ch.:  102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 ---------  ------------------  ---------------------------------------------
 WORDNO.         CONTENT                           COMMENT
 ---------  ------------------  ---------------------------------------------
 449- 451    704     11    8     No., record pointer, word pointer of ch.:  124
 452- 454    705     11   68     No., record pointer, word pointer of ch.:  125
 455- 457    706     11  128     No., record pointer, word pointer of ch.:  126
 458- 460    709     11  176     No., record pointer, word pointer of ch.:  127
 461- 463    711     11  283     No., record pointer, word pointer of ch.:  128
 464- 466    751     11  370     No., record pointer, word pointer of ch.:  129
 467- 469    753     11  493     No., record pointer, word pointer of ch.:  130
 470- 472    754     11  639     No., record pointer, word pointer of ch.:  131
 473- 475    755     11  699     No., record pointer, word pointer of ch.:  132
 476- 478    756     11  759     No., record pointer, word pointer of ch.:  133
 479- 481    759     11  807     No., record pointer, word pointer of ch.:  134
 482- 484    761     11  914     No., record pointer, word pointer of ch.:  135

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```

```
AN201512.VS                     5-MAR-87                      PAGE    5

 ---------|-------------------|---------------------------------------------------
 WORDNO.  |      CONTENT      |                    COMMENT
 ---------|-------------------|---------------------------------------------------
     1    |                 0 | Records      length of character
     2    |               239 | Words
 ---------|-------------------|---------------------------------------------------
       NAME SECTION
       ------------
     3    |                 3 | Length of name section
     4    |               301 | Character number
     5    |                 0 | Number of following part
 ---------|-------------------|---------------------------------------------------
       SETTING INFORMATION
       -------------------
     6    |                29 | Length of setting information
     7    |                11 | Character type = small letter
     8    |               136 | Number of vectors
     9    |               555 | Total set width (T=L+W+R)
    10    |                40 | Left side bearing (L)
    11    |               524 | Width (W)
    12    |                -9 | Right side bearing (R)
    13    |                 0 | X-minimum
    14    |               524 | X-maximum
    15    |               -11 | Y-minimum
    16    |               515 | Y-maximum
    17    |                 1 | Unit is 1 pixel
    18    |                 2 | Stem information for contours 1 - 2
    19    |                 2 | Number of vertical straight lines
    20    |             16803 | Absolute value (in pixels)  419
    21    |               -94 | Relative value (in pixels)
    22    |                 5 | Number of vertical curve extrema
    23    |             16384 | Absolute value (in pixels)    0
    24    |                97 | Relative value (in pixels)
    25    |             16431 | Absolute value (in pixels)   47
    26    |                97 | Relative value (in pixels)
    27    |             16553 | Absolute value (in pixels)  169
    28    |                 0 | Number of horizontal straight lines
    29    |                 5 | Number of horizontal curve extrema
    30    |             16373 | Absolute value (in pixels)  -11
    31    |                54 | Relative value (in pixels)
    32    |             16899 | Absolute value (in pixels)  515
    33    |               -36 | Relative value (in pixels)
    34    |             16727 | Absolute value (in pixels)  343
 ---------|-------------------|---------------------------------------------------
       CONTOUR INDEX
       -------------
    35    |                 0 | Records     length of contour index
    36    |                14 | Words
          |                   |
    37    |                 0 | Record pointer for   1. contour:     0
    38    |                 3 | Word pointer                    :    51
    39    |                -1 | Sense of rotation of contour = clockwise
    40    |                 0 | Nesting: outer  1. order
    41    |                 0 | Colour inside: transparent
    42    |               108 | Number of digitizations
          |                   |
    43    |                 0 | Record pointer for   2. contour:     0
    44    |               153 | Word pointer                    :   201
    45    |                 1 | Sense of rotation of contour = counterclockwise
    46    |                 1 | Nesting: inner  1. order
    47    |                 0 | Colour inside: transparent
    48    |                28 | Number of digitizations
 ---------|-------------------|---------------------------------------------------
```

```
AN201512.VS                    5-MAR-87                    PAGE   6

|---------|------------------|--------------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                       |
|---------|------------------|--------------------------------------------------|
|     IMAGE INFORMATION
|     -----------------
|   49    |                0 | Records     length of image information
|   50    |              191 | Words
|
|  51 -200|    325      76   |    325    76    (dX,dY)          1.DIG w-vector
|   53 1  | 7E   FA   00     | 126   -6    0    (K,dX,dY)        2.DIG s-vector
|   54 2  |      EF   EE     |      -17  -18     (dX,dY)         3.DIG s-vector
|   55 2  |      F7   F8     |       -9   -8     (dX,dY)         4.DIG s-vector
|   56 2  |      EC   EF     |      -20  -17     (dX,dY)         5.DIG s-vector
|   57 2  |      EA   F1     |      -22  -15     (dX,dY)         6.DIG s-vector
|   58 2  | 7D   E5   F3  FE | 125  -27  -13  -2 (K,dX,dY,dS)    7.DIG c-vector
|   60 2  |      E4   F6  FE |      -28  -10  -2  (dX,dY,dS)     8.DIG c-vector
|   62 1  | 7E   E8   FC     | 126  -24   -4     (K,dX,dY)       9.DIG s-vector
|   63 2  |      E8   FE     |      -24   -2      (dX,dY)       10.DIG s-vector
|   64 2  | 7D   D7   04  FB | 125  -41    4  -5 (K,dX,dY,dS)   11.DIG c-vector
|   66 2  |      DC   0D  FB |      -36   13  -5  (dX,dY,dS)    12.DIG c-vector
|   68 1  |      DE   1A  F9 |      -34   26  -7  (dX,dY,dS)    13.DIG c-vector
|   69 2  |      E9   22  F9 |      -23   34  -7  (dX,dY,dS)    14.DIG c-vector
|   71 1  |      F5   22  FC |      -11   34  -4  (dX,dY,dS)    15.DIG c-vector
|   72 2  |      FD   26  FC |       -3   38  -4  (dX,dY,dS)    16.DIG c-vector
|   74 1  |      03   1D  FE |        3   29  -2  (dX,dY,dS)    17.DIG c-vector
|   75 2  |      07   19  FE |        7   25  -2  (dX,dY,dS)    18.DIG c-vector
|   77 1  |      0D   19  FD |       13   25  -3  (dX,dY,dS)    19.DIG c-vector
|   78 2  |      10   12  FD |       16   18  -3  (dX,dY,dS)    20.DIG c-vector
|   80 1  |      20   16  FC |       32   22  -4  (dX,dY,dS)    21.DIG c-vector
|   81 2  |      27   10  FC |       39   16  -4  (dX,dY,dS)    22.DIG c-vector
|   83 1  | 7E   21   08     | 126   33    8     (K,dX,dY)      23.DIG s-vector
|   84 2  |      27   07     |       39    7      (dX,dY)       24.DIG s-vector
|   85 2  |      29   06     |       41    6      (dX,dY)       25.DIG s-vector
|   86 2  |      5C   11     |       92   17      (dX,dY)       26.DIG s-vector
|   87 2  | 85               |-123                         is a vertical peak
|   88 1  |      08   0C     |        8   12      (dX,dY)       27.DIG s-vector
|   89 1  |      00   15     |        0   21      (dX,dY)       28.DIG s-vector
|   90 1  |      00   0B     |        0   11      (dX,dY)       29.DIG s-vector
|   91 1  |      FD   14     |       -3   20      (dX,dY)       30.DIG s-vector
|   92 1  |      FC   14     |       -4   20      (dX,dY)       31.DIG s-vector
|   93 1  | 7D   F4   21  03 | 125  -12   33   3 (K,dX,dY,dS)   32.DIG c-vector
|   95 1  |      F2   15  03 |      -14   21   3  (dX,dY,dS)    33.DIG c-vector
|   96 2  |      F0   0D  03 |      -16   13   3  (dX,dY,dS)    34.DIG c-vector
|   98 1  |      E7   0B  03 |      -25   11   3  (dX,dY,dS)    35.DIG c-vector
|   99 2  |      EB   05  02 |      -21    5   2  (dX,dY,dS)    36.DIG c-vector
|  101 1  |      EB   01  02 |      -21    1   2  (dX,dY,dS)    37.DIG c-vector
|  102 2  | 7E   F0   FE     | 126  -16   -2     (K,dX,dY)      38.DIG s-vector
|  104 1  |      F2   FD     |      -14   -3      (dX,dY)       39.DIG s-vector
|  105 1  |      F6   FD     |      -10   -3      (dX,dY)       40.DIG s-vector
|  106 1  |      F9   FD     |       -7   -3      (dX,dY)       41.DIG s-vector
|  107 1  |      FB   FD     |       -5   -3      (dX,dY)       42.DIG s-vector
|  108 1  |      FB   FC     |       -5   -4      (dX,dY)       43.DIG s-vector
|  109 1  |      FB   FB     |       -5   -5      (dX,dY)       44.DIG s-vector
|  110 1  |      FF   FD     |       -1   -3      (dX,dY)       45.DIG s-vector
|  111 1  |      01   FD     |        1   -3      (dX,dY)       46.DIG s-vector
|  112 1  |      03   FB     |        3   -5      (dX,dY)       47.DIG s-vector
|  113 1  |      08   F7     |        8   -9      (dX,dY)       48.DIG s-vector
|  114 1  |      06   F9     |        6   -7      (dX,dY)       49.DIG s-vector
|  115 1  |      04   F7     |        4   -9      (dX,dY)       50.DIG s-vector
|  116 1  |      02   F7     |        2   -9      (dX,dY)       51.DIG s-vector
|---------|------------------|--------------------------------------------------|
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|---------|------------------|-------------------------------------------------|
| WORDNO. |      CONTENT     |                    COMMENT                      |
|---------|------------------|-------------------------------------------------|
  117 1        01    F6             1 -10        (dX,dY)          52.DIG s-vector
  118 1  7D    FE    F2   FE   125   -2 -14   -2 (K,dX,dY,dS)     53.DIG c-vector
  120 1        FB    F2   FE         -5 -14   -2   (dX,dY,dS)     54.DIG c-vector
  121 2        F6    F3   FD        -10 -13   -3   (dX,dY,dS)     55.DIG c-vector
  123 1        F3    F6   FD        -13 -10   -3   (dX,dY,dS)     56.DIG c-vector
  124 2        F0    FB   FE        -16  -5   -2   (dX,dY,dS)     57.DIG c-vector
  126 1        EF    FE   FE        -17  -2   -2   (dX,dY,dS)     58.DIG c-vector
  127 2  7E    F1    02        126  -15   2      (K,dX,dY)        59.DIG s-vector
  129 1        F6    03             -10   3        (dX,dY)        60.DIG s-vector
  130 1  7D    F0    0C   FC   125  -16  12   -4 (K,dX,dY,dS)     61.DIG c-vector
  132 1        F4    11   FC        -12  17   -4   (dX,dY,dS)     62.DIG c-vector
  133 2        FB    10   FE         -5  16   -2   (dX,dY,dS)     63.DIG c-vector
  135 1        FF    11   FE         -1  17   -2   (dX,dY,dS)     64.DIG c-vector
  136 2  7E    02    0F        126    2  15      (K,dX,dY)        65.DIG s-vector
  138 1        05    0E               5  14        (dX,dY)        66.DIG s-vector
  139 1  7D    0C    15   FD   125   12  21   -3 (K,dX,dY,dS)     67.DIG c-vector
  141 1        10    10   FD         16  16   -3   (dX,dY,dS)     68.DIG c-vector
  142 2        1D    12   FC         29  18   -4   (dX,dY,dS)     69.DIG c-vector
  144 1        21    0B   FC         33  11   -4   (dX,dY,dS)     70.DIG c-vector
  145 2        23    07   FE         35   7   -2   (dX,dY,dS)     71.DIG c-vector

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|---------|------------------|-------------------------------------------------|
| WORDNO. |      CONTENT     |                    COMMENT                      |
|---------|------------------|-------------------------------------------------|
  199 1        F9    13              -7  19        (dX,dY)       107.DIG s-vector
  200 1        FB    12              -5  18        (dX,dY)       108.DIG s-vector
 201 -239        0      198           0     198    (dX,dY)       109.DIG w-vector
  203 1  7E    F9    04        126   -7   4      (K,dX,dY)       110.DIG s-vector
  204 2  85                   -123                            is a vertical peak
  205 1        C6    F6             -58 -10        (dX,dY)       111.DIG s-vector
  206 1        E3    FA             -29  -6        (dX,dY)       112.DIG s-vector
  207 1        DD    F7             -35  -9        (dX,dY)       113.DIG s-vector
  208 1        E4    F8             -28  -8        (dX,dY)       114.DIG s-vector
  209 1        EB    F7             -21  -9        (dX,dY)       115.DIG s-vector
  210 1  7D    EA    F0   04   125  -22 -16    4 (K,dX,dY,dS)    116.DIG c-vector
  212 1        F0    EA   04        -16 -22    4   (dX,dY,dS)    117.DIG c-vector
  213 2        F8    EB   03         -8 -21    3   (dX,dY,dS)    118.DIG c-vector
  215 1        FC    E2   03         -4 -30    3   (dX,dY,dS)    119.DIG c-vector
  216 2        02    E6   03          2 -26    3   (dX,dY,dS)    120.DIG c-vector
  218 1        08    E8   03          8 -24    3   (dX,dY,dS)    121.DIG c-vector
  219 2        0D    EA   04         13 -22    4   (dX,dY,dS)    122.DIG c-vector
  221 1        15    EF   04         21 -17    4   (dX,dY,dS)    123.DIG c-vector
  222 2        18    F5   04         24 -11    4   (dX,dY,dS)    124.DIG c-vector
  224 1        1D    FC   04         29  -4    4   (dX,dY,dS)    125.DIG c-vector
  225 2        1C    03   03         28   3    3   (dX,dY,dS)    126.DIG c-vector
  227 1        1A    08   03         26   8    3   (dX,dY,dS)    127.DIG c-vector
  228 2        18    0E   03         24  14    3   (dX,dY,dS)    128.DIG c-vector
  230 1        14    11   03         20  17    3   (dX,dY,dS)    129.DIG c-vector
  231 2        0D    11   02         13  17    2   (dX,dY,dS)    130.DIG c-vector
  233 1        08    10   02          8  16    2   (dX,dY,dS)    131.DIG c-vector
  234 2  7E    06    13        126    6  19      (K,dX,dY)       132.DIG s-vector
  236 1        04    1A               4  26        (dX,dY)       133.DIG s-vector
  237 1        02    11               2  17        (dX,dY)       134.DIG s-vector
  238 1        00    0F               0  15        (dX,dY)       135.DIG s-vector
  239 1        00    4F               0  79        (dX,dY)       136.DIG s-vector

|---------|------------------|-------------------------------------------------|
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|---------|-------------------|--------------------------------------------------|
| WORDNO. |      CONTENT      |                      COMMENT                     |
|---------|-------------------|--------------------------------------------------|
|    1    |                 0 | Records      length of character                 |
|    2    |               179 | Words                                            |
|---------|-------------------|--------------------------------------------------|
|      NAME SECTION           |                                                  |
|      ------------           |                                                  |
|    3    |                 3 | Length of name section                           |
|    4    |               302 | Character number                                 |
|    5    |                 0 | Number of following part                         |
|---------|-------------------|--------------------------------------------------|
|      SETTING INFORMATION    |                                                  |
|      -------------------    |                                                  |
|    6    |                27 | Length of setting information                    |
|    7    |                11 | Character type = small letter                    |
|    8    |                89 | Number of vectors                                |
|    9    |               694 | Total set width (T=L+W+R)                        |
|   10    |                 0 | Left side bearing (L)                            |
|   11    |               640 | Width (W)                                        |
|   12    |                54 | Right side bearing (R)                           |
|   13    |                 0 | X-minimum                                        |
|   14    |               640 | X-maximum                                        |
|   15    |               -14 | Y-minimum                                        |
|   16    |               756 | Y-maximum                                        |
|   17    |                 1 | Unit is 1 pixel                                  |
|   18    |                 2 | Stem information for contours 1 - 2              |
|   19    |                 2 | Number of vertical straight lines                |
|   20    |             16501 | Absolute value (in pixels)   117                 |
|   21    |                94 | Relative value (in pixels)                       |
|   22    |                 3 | Number of vertical curve extrema                 |
|   23    |             17024 | Absolute value (in pixels)   640                 |
|   24    |              -119 | Relative value (in pixels)                       |
|   25    |             16594 | Absolute value (in pixels)   210                 |
|   26    |                 0 | Number of horizontal straight lines              |
|   27    |                 5 | Number of horizontal curve extrema               |
|   28    |             16373 | Absolute value (in pixels)   -11                 |
|   29    |                36 | Relative value (in pixels)                       |
|   30    |             16899 | Absolute value (in pixels)   515                 |
|   31    |               -36 | Relative value (in pixels)                       |
|   32    |             16427 | Absolute value (in pixels)    43                 |
|---------|-------------------|--------------------------------------------------|
|      CONTOUR INDEX          |                                                  |
|      -------------          |                                                  |
|   33    |                 0 | Records     length of contour index              |
|   34    |                14 | Words                                            |
|         |                   |                                                  |
|   35    |                 0 | Record pointer for   1. contour:      0          |
|   36    |                 3 | Word pointer                     :    49         |
|   37    |                -1 | Sense of rotation of contour = clockwise         |
|   38    |                 0 | Nesting: outer  1. order                         |
|   39    |                 0 | Colour inside: transparent                       |
|   40    |                56 | Number of digitizations                          |
|         |                   |                                                  |
|   41    |                 0 | Record pointer for   2. contour:      0          |
|   42    |                84 | Word pointer                     :   130         |
|   43    |                 1 | Sense of rotation of contour = counterclockwise  |
|   44    |                 1 | Nesting: inner  1. order                         |
|   45    |                 0 | Colour inside: transparent                       |
|   46    |                33 | Number of digitizations                          |
|         |                   |                                                  |
|---------|-------------------|--------------------------------------------------|
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|---------|------------------|--------------------------------------------------|
| WORDNO. |      CONTENT     |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|  121 2  | 7D   FB   FE  02 | 125   -5  -2   2 (K,dX,dY,dS)    51.DIG c-vector |
|  123 2  |      F6   F8  02 |      -10  -8   2   (dX,dY,dS)    52.DIG c-vector |
|  125 1  | 7E   FA   F9     | 126   -6  -7     (K,dX,dY)       53.DIG s-vector |
|  126 2  |      F8   F7     |       -8  -9       (dX,dY)       54.DIG s-vector |
|  127 2  |      F2   EE     |      -14 -18       (dX,dY)       55.DIG s-vector |
|  128 2  |      F5   F3     |      -11 -13       (dX,dY)       56.DIG s-vector |
| 130 -179|        66    266 |         66   266   (dX,dY)       57.DIG w-vector |
|  132 1  | 7E   01   D4     | 126    1 -44     (K,dX,dY)       58.DIG s-vector |
|  133 2  |      03   DB     |        3 -37       (dX,dY)       59.DIG s-vector |
|  134 2  | 7D   0D   D0  06 | 125   13 -48   6 (K,dX,dY,dS)    60.DIG c-vector |
|  136 2  |      16   D7  06 |       22 -41   6   (dX,dY,dS)    61.DIG c-vector |
|  138 1  |      15   EA  04 |       21 -22   4   (dX,dY,dS)    62.DIG c-vector |
|  139 2  |      1D   ED  04 |       29 -19   4   (dX,dY,dS)    63.DIG c-vector |
|  141 1  |      20   F4  04 |       32 -12   4   (dX,dY,dS)    64.DIG c-vector |
|  142 2  |      1F   FC  04 |       31  -4   4   (dX,dY,dS)    65.DIG c-vector |
|  144 1  |      21   04  04 |       33   4   4   (dX,dY,dS)    66.DIG c-vector |
|  145 2  |      21   0D  04 |       33  13   4   (dX,dY,dS)    67.DIG c-vector |
|  147 1  |      19   10  03 |       25  16   3   (dX,dY,dS)    68.DIG c-vector |
|  148 2  |      14   14  03 |       20  20   3   (dX,dY,dS)    69.DIG c-vector |
|  150 1  |      1A   2C  07 |       26  44   7   (dX,dY,dS)    70.DIG c-vector |
|  151 2  |      10   35  07 |       16  53   7   (dX,dY,dS)    71.DIG c-vector |
|  153 1  |      05   2D  02 |        5  45   2   (dX,dY,dS)    72.DIG c-vector |
|  154 2  |      01   31  02 |        1  49   2   (dX,dY,dS)    73.DIG c-vector |
|  156 1  |      FD   2E  02 |       -3  46   2   (dX,dY,dS)    74.DIG c-vector |
|  157 2  |      F9   29  02 |       -7  41   2   (dX,dY,dS)    75.DIG c-vector |
|  159 1  |      F3   27  04 |      -13  39   4   (dX,dY,dS)    76.DIG c-vector |
|  160 2  |      EC   21  04 |      -20  33   4   (dX,dY,dS)    77.DIG c-vector |
|  162 1  |      EB   15  04 |      -21  21   4   (dX,dY,dS)    78.DIG c-vector |
|  163 2  |      E2   11  04 |      -30  17   4   (dX,dY,dS)    79.DIG c-vector |
|  165 1  |      E4   09  03 |      -28   9   3   (dX,dY,dS)    80.DIG c-vector |
|  166 2  |      E2   04  03 |      -30   4   3   (dX,dY,dS)    81.DIG c-vector |
|  168 1  |      DD   FD  04 |      -35  -3   4   (dX,dY,dS)    82.DIG c-vector |
|  169 2  |      DE   F4  04 |      -34 -12   4   (dX,dY,dS)    83.DIG c-vector |
|  171 1  |      E1   EC  05 |      -31 -20   5   (dX,dY,dS)    84.DIG c-vector |
|  172 2  |      E8   E6  05 |      -24 -26   5   (dX,dY,dS)    85.DIG c-vector |
|  174 1  |      EE   DF  05 |      -18 -33   5   (dX,dY,dS)    86.DIG c-vector |
|  175 2  |      F5   D6  05 |      -11 -42   5   (dX,dY,dS)    87.DIG c-vector |
|  177 1  |      FC   D7  02 |       -4 -41   2   (dX,dY,dS)    88.DIG c-vector |
|  178 2  |      FE   CE  02 |       -2 -50   2   (dX,dY,dS)    89.DIG c-vector |
|         |                  |                                                  |
|---------|------------------|--------------------------------------------------|
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|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
|    1    |                0 | Records      length of character              |
|    2    |              161 | Words                                         |
|---------|------------------|-----------------------------------------------|
|      NAME SECTION                                                          |
|      ------------                                                          |
|    3    |                3 | Length of name section                        |
|    4    |              303 | Character number                              |
|    5    |                0 | Number of following part                      |
|---------|------------------|-----------------------------------------------|
|      SETTING INFORMATION                                                   |
|      -------------------                                                   |
|    6    |               27 | Length of setting information                 |
|    7    |               11 | Character type = small letter                 |
|    8    |               89 | Number of vectors                             |
|    9    |              533 | Total set width (T=L+W+R)                     |
|   10    |               54 | Left side bearing (L)                         |
|   11    |              450 | Width (W)                                     |
|   12    |               29 | Right side bearing (R)                        |
|   13    |                0 | X-minimum                                     |
|   14    |              450 | X-maximum                                     |
|   15    |              -11 | Y-minimum                                     |
|   16    |              515 | Y-maximum                                     |
|   17    |                1 | Unit is 1 pixel                               |
|   18    |                1 | Stem information for contours 1 - 1           |
|   19    |                0 | Number of vertical straight lines             |
|   20    |                5 | Number of vertical curve extrema              |
|   21    |            16384 | Absolute value (in pixels)     0              |
|   22    |              119 | Relative value (in pixels)                    |
|   23    |            16834 | Absolute value (in pixels)   450              |
|   24    |              -97 | Relative value (in pixels)                    |
|   25    |            16709 | Absolute value (in pixels)   325              |
|   26    |                0 | Number of horizontal straight lines           |
|   27    |                5 | Number of horizontal curve extrema            |
|   28    |            16373 | Absolute value (in pixels)   -11              |
|   29    |               54 | Relative value (in pixels)                    |
|   30    |            16899 | Absolute value (in pixels)   515              |
|   31    |              -36 | Relative value (in pixels)                    |
|   32    |            16710 | Absolute value (in pixels)   326              |
|---------|------------------|-----------------------------------------------|
|      CONTOUR INDEX                                                         |
|      -------------                                                         |
|   33    |                0 | Records     length of contour index           |
|   34    |                8 | Words                                         |
|         |                  |                                               |
|   35    |                0 | Record pointer for   1. contour:     0        |
|   36    |                3 | Word pointer                    :    43       |
|   37    |               -1 | Sense of rotation of contour = clockwise      |
|   38    |                0 | Nesting: outer   1. order                     |
|   39    |                0 | Colour inside: transparent                    |
|   40    |               89 | Number of digitizations                       |
|         |                  |                                               |
|---------|------------------|-----------------------------------------------|
|      IMAGE INFORMATION                                                     |
|      -----------------                                                     |
|   41    |                0 | Records     length of image information      |
|   42    |              121 | Words                                         |
|         |                  |                                               |
|  43 -161|       432     104|        432   104   (dX,dY)       1.DIG w-vector|
|   45 1  | 85               |-123                         is a vertical peak|
|---------|------------------|-----------------------------------------------|
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| --------- | ----------------- | ------------------------------------------------- |
|  WORDNO.  |      CONTENT      |                     COMMENT                       |
| --------- | ----------------- | ------------------------------------------------- |
|    45 2   | 7E  0C  E8        |  126   12 -24      (K,dX,dY)        2.DIG s-vector |
|    47 1   | 86                | -122                        is a horizontal peak |
|    47 2   |     F1  F0        |       -15 -16       (dX,dY)         3.DIG s-vector |
|    48 2   |     F8  F9        |        -8  -7       (dX,dY)         4.DIG s-vector |
|    49 2   | 7D  E8  ED  FE    |  125  -24 -19  -2 (K,dX,dY,dS)      5.DIG c-vector |
|    51 2   |     E5  F0  FE    |       -27 -16  -2   (dX,dY,dS)      6.DIG c-vector |
|    53 1   |     E2  F2  FE    |       -30 -14  -2   (dX,dY,dS)      7.DIG c-vector |
|    54 2   |     DF  F6  FE    |       -33 -10  -2   (dX,dY,dS)      8.DIG c-vector |
|    56 1   |     DC  F9  FE    |       -36  -7  -2   (dX,dY,dS)      9.DIG c-vector |
|    57 2   |     DD  FE  FE    |       -35  -2  -2   (dX,dY,dS)     10.DIG c-vector |
|    59 1   |     D4  04  FC    |       -44   4  -4   (dX,dY,dS)     11.DIG c-vector |
|    60 2   |     D8  0B  FC    |       -40  11  -4   (dX,dY,dS)     12.DIG c-vector |
|    62 1   |     D8  14  FB    |       -40  20  -5   (dX,dY,dS)     13.DIG c-vector |
|    63 2   |     DE  1A  FB    |       -34  26  -5   (dX,dY,dS)     14.DIG c-vector |
|    65 1   |     DF  29  FA    |       -33  41  -6   (dX,dY,dS)     15.DIG c-vector |
|    66 2   |     E7  31  FA    |       -25  49  -6   (dX,dY,dS)     16.DIG c-vector |
|    68 1   |     F1  38  FB    |       -15  56  -5   (dX,dY,dS)     17.DIG c-vector |
|    69 2   |     FB  3B  FB    |        -5  59  -5   (dX,dY,dS)     18.DIG c-vector |
|    71 1   |     04  37  FB    |         4  55  -5   (dX,dY,dS)     19.DIG c-vector |
|    72 2   |     0E  34  FB    |        14  52  -5   (dX,dY,dS)     20.DIG c-vector |
```

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| --------- | ----------------- | ------------------------------------------------- |
|  WORDNO.  |      CONTENT      |                     COMMENT                       |
| --------- | ----------------- | ------------------------------------------------- |
|   122 2   |     F8  08        |        -8   8       (dX,dY)        60.DIG s-vector |
|   123 2   |     F7  07        |        -9   7       (dX,dY)        61.DIG s-vector |
|   124 2   |     F4  06        |       -12   6       (dX,dY)        62.DIG s-vector |
|   125 2   |     F1  04        |       -15   4       (dX,dY)        63.DIG s-vector |
|   126 2   |     F0  03        |       -16   3       (dX,dY)        64.DIG s-vector |
|   127 2   |     EF  01        |       -17   1       (dX,dY)        65.DIG s-vector |
|   128 2   | 7D  E2  FD  03    |  125  -30  -3   3 (K,dX,dY,dS)     66.DIG c-vector |
|   130 2   |     E3  F6  03    |       -29 -10   3   (dX,dY,dS)     67.DIG c-vector |
|   132 1   |     E6  F1  03    |       -26 -15   3   (dX,dY,dS)     68.DIG c-vector |
|   133 2   |     EF  F0  03    |       -17 -16   3   (dX,dY,dS)     69.DIG c-vector |
|   135 1   |     EB  E2  04    |       -21 -30   4   (dX,dY,dS)     70.DIG c-vector |
|   136 2   |     F1  D9  04    |       -15 -39   4   (dX,dY,dS)     71.DIG c-vector |
|   138 1   |     F6  CA  04    |       -10 -54   4   (dX,dY,dS)     72.DIG c-vector |
|   139 2   |     FD  C9  04    |        -3 -55   4   (dX,dY,dS)     73.DIG c-vector |
|   141 1   |     03  CE  03    |         3 -50   3   (dX,dY,dS)     74.DIG c-vector |
|   142 2   |     09  D5  03    |         9 -43   3   (dX,dY,dS)     75.DIG c-vector |
|   144 1   |     11  D7  06    |        17 -41   6   (dX,dY,dS)     76.DIG c-vector |
|   145 2   |     1B  DC  06    |        27 -36   6   (dX,dY,dS)     77.DIG c-vector |
|   147 1   |     17  EE  03    |        23 -18   3   (dX,dY,dS)     78.DIG c-vector |
|   148 2   |     1A  F2  03    |        26 -14   3   (dX,dY,dS)     79.DIG c-vector |
|   150 1   |     1E  F7  03    |        30  -9   3   (dX,dY,dS)     80.DIG c-vector |
|   151 2   |     23  FD  03    |        35  -3   3   (dX,dY,dS)     81.DIG c-vector |
|   153 1   | 7E  13  01        |  126   19   1      (K,dX,dY)       82.DIG s-vector |
|   154 2   |     15  04        |        21   4       (dX,dY)        83.DIG s-vector |
|   155 2   |     17  06        |        23   6       (dX,dY)        84.DIG s-vector |
|   156 2   |     14  08        |        20   8       (dX,dY)        85.DIG s-vector |
|   157 2   |     15  0B        |        21  11       (dX,dY)        86.DIG s-vector |
|   158 2   |     13  0D        |        19  13       (dX,dY)        87.DIG s-vector |
|   159 2   |     07  06        |         7   6       (dX,dY)        88.DIG s-vector |
|   160 2   |     0D  0C        |        13  12       (dX,dY)        89.DIG s-vector |
|           |                   |                                                   |
| --------- | ----------------- | ------------------------------------------------- |
AN201512.VS                   5-MAR-87                    PAGE  15

-------------------------------------------------------------------------
|                         GRAND TOTAL                                   |
|                         -----------                                   |
|                                              WORDS         KBYTES      |
|                                              -----         ------      |
|  Length of font:                            21480         42.960      |
|  Length of font header:                       484          0.968      |
|  Length of all character headers:            5546         11.092      |
|  Length of total image information:         15450         30.900      |
|           DIGITIZATIONS                           NUMBER               |
|           -------------                           ------               |
|           White vectors:                             227               |
|           L-vectors:                                 441               |
|           S-vectors:                                4242               |
|           C-vectors:                                5528               |
|                                                   ======               |
|           Total:                                   10438               |
|           ---------------------------------------------               |
|           Serif starts:                              150               |
|           Serif ends:                                150               |
|           Horizontal peaks:                           81               |
|           Vertical peaks:                            107               |
|           ---------------------------------------------               |
|           Characters:                                135               |
|           Records (a 2048 words):                     11               |
|           ---------------------------------------------               |
|           Raster (grid):                    1080 X  1080               |
|           ---------------------------------------------               |
|           Digitizations per character:                77               |
|           Image information per character:           228 bytes        |
-------------------------------------------------------------------------
                       VS - CHORD HEIGHT - STATISTICS
                        (Unit is quarter pixel)

                 Number of chords with height    2 =   1011
                 Number of chords with height    3 =    825
                 Number of chords with height    4 =    323
                 Number of chords with height    5 =    145
                 Number of chords with height    6 =     92
                 Number of chords with height    7 =     74
                 Number of chords with height    8 =     24
                 Number of chords with height    9 =     10
                 Number of chords with height   10 =      6
                 Number of chords with height   17 =      4
                 Number of chords with height   18 =      4
                 Number of chords with height   -2 =   1175
                 Number of chords with height   -3 =    745
                 Number of chords with height   -4 =    362
                 Number of chords with height   -5 =    244
                 Number of chords with height   -6 =    120
                 Number of chords with height   -7 =     90
                 Number of chords with height   -8 =     54
                 Number of chords with height   -9 =     45
                 Number of chords with height  -10 =     15
                 Number of chords with height  -11 =      6

                 Number of chords with height  -21 =     80
                 Number of chords with height  -22 =      4
                 Number of chords with height  -23 =      8
                 Number of chords with height  -24 =      8
                 Number of chords with height  -28 =      8
```

Appendix M
Description of the VE format

1. Structure of a VE font

For the structure of a VE font see appendices G and K, extended structure.

2. Description of the VE format

The **vector format** is a simplified form of the VC format. The arcs are no longer described as circles but divided into vectors and then coded.

The curved sections of an IK type font comprise almost 90% of the image information. As already mentioned (chapter 5.1.4), raster images seldom have long straight sections in curved parts with more than 13 contour pixels.

This fact has led to an incremental coding in which an 8 bit byte is sufficient for a vector. Such vectors are known as V vectors. The left 4 bits (higher value) describe the X increment of the V vector, the right 4 bits (lower value) the Y increment.

The amounts ΔX and ΔY of the V vectors are kept smaller than 14. The sign is determined specially for each case.

As in the case of a VC format, there are also white vectors which run to the start of the contours with pen "raised". They start on the word boundary at the beginning of the contour data. The associated ΔX and ΔY values are INTEGER × 2 with sign. The first white vector starts at the zero point of the appropriate coordinate system of the character. The subsequent white vectors then start at the ends of the preceding contours and lead to the following contour in a sequence as given by the contour index.

Longer straights cannot, of course, be described with V vectors. For this reason we have introduced the following system (hexadecimal notation).

The vectors E0...ED indicate that the X components are first described in the following byte. In doing so the byte values 1...120 are taken as positive and the values 255...136 are counted as negative, as $-1 \ldots -120$. We call this the S vector method.

From now on the X components of the vectors have the sign given here. Vectors F0...FD are in effect the same and additionally change the sign of the following Y components.
If the following byte is coded with 80 then the coding, as INTEGER × 2 with sign, follows in the next 2 bytes (16 bit). We call this the L vector method. The sign of the components also applies to the subsequent V vectors.
Correspondingly the vectors OE...DE and OF...DF mean that the Y components are first described in the following byte or following 3 bytes. Byte EE, EF, FE or FF mean that first the X, and then the Y components are described as discussed previously.
The switch-over of the sign for the short increments ΔX and ΔY of the V vectors is carried out by calling up the longer code (either 8 or 16 bit) for one or, in some cases, both components. The stating of F0...FD or 0F...DF allows simultaneous switching of the sign of the other respective component. This switch-over first applies, however, from the next V vector onwards and not for the vector currently being dealt with.

Coding examples: sequence of increments

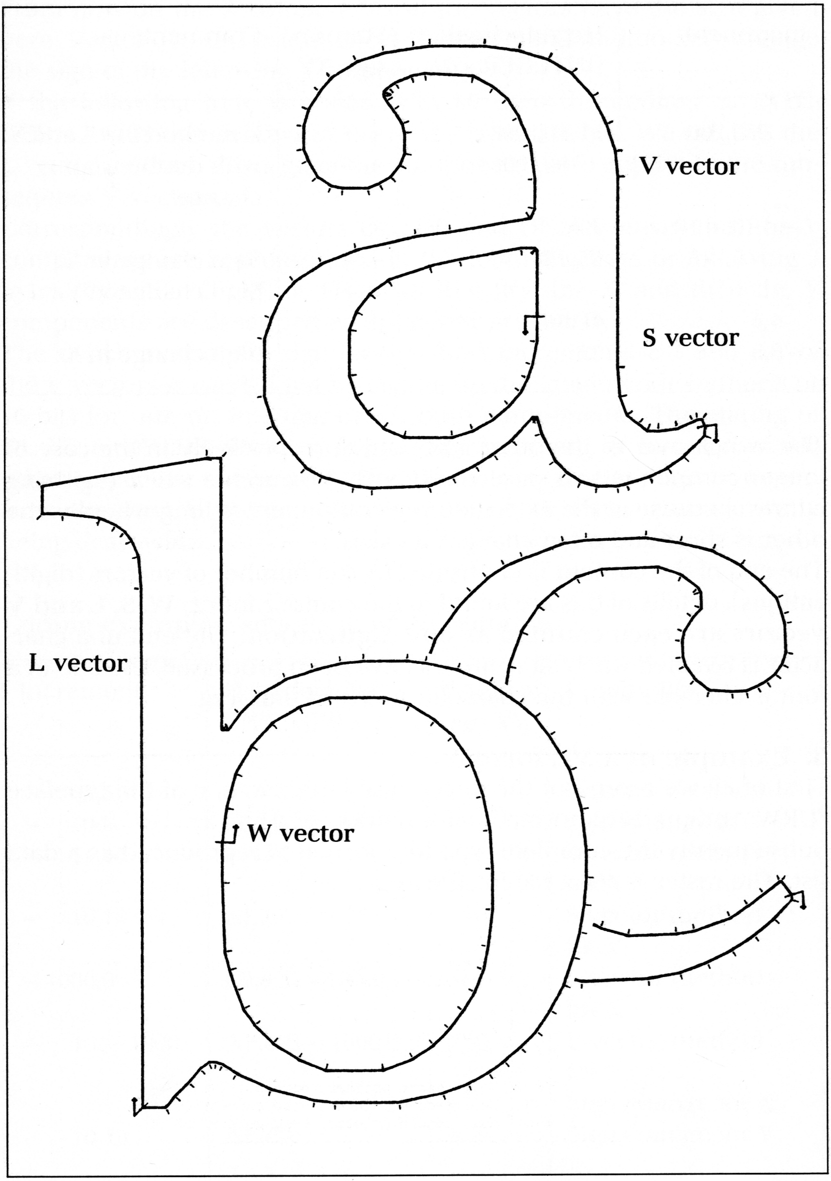
Increment	Hexadecimal (INTEGER × 2)	Status of sign XY	Comments
5,5	55	+ +	Normal V vector
– 10,0	E0,F6	– +	Sign change in X
– 14,10	EA,F2	– +	S vector method for X
– 10,14	AE,0E	– +	S vector method for Y
– 1000,0	E0,80,(– 1000)	– +	L vector method for X
– 10, – 1000	AF,80,(– 1000)	– –	L vector method for Y
		+ –	Sign change for X
10,10	AE,0A	+ +	Sign change for Y

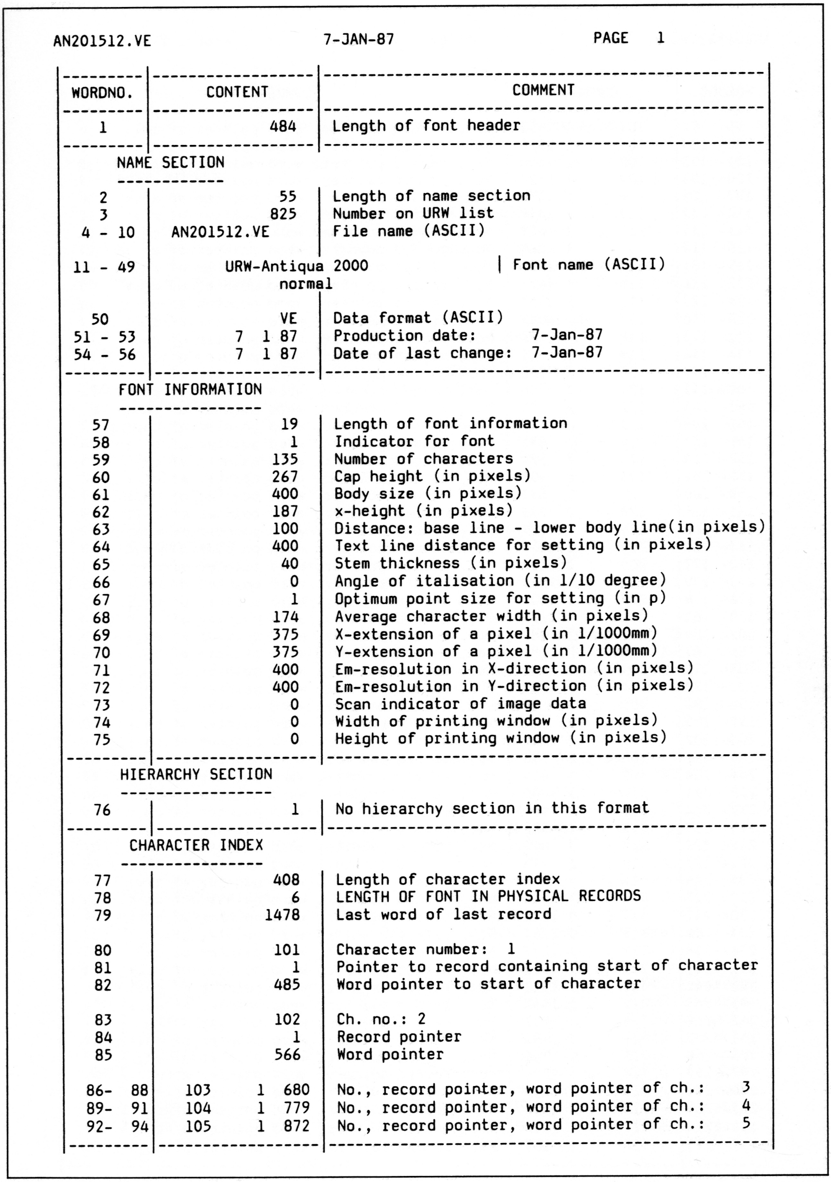
Increment	Hexadecimal (INTEGER × 2)	Status of sign XY	Comments
200,200	FF,80,(200), 80,(200)	+ + – –	L method for X and Y with double sign change
– 10, – 10	AA		
5, – 5	F5,05	+ –	Sign change in X
		+ +	Sign change in Y
4,4	4F,04		
– 3,3	33	– +	Sign change in X

The switch-over of the other component respectively in the case of longer components, is particularly very favourable when digitizing curves; because at the extremes one component is long whereas the other is short and often changes its sign.
The end of the contour is controlled by the number of vectors (digitizations), details of this are found in the contour index. **W, S, L and V vectors are each counted as one digitization.** The end of a character is reached when all contours have been processed.The end of a font is checked with the character index of that font.

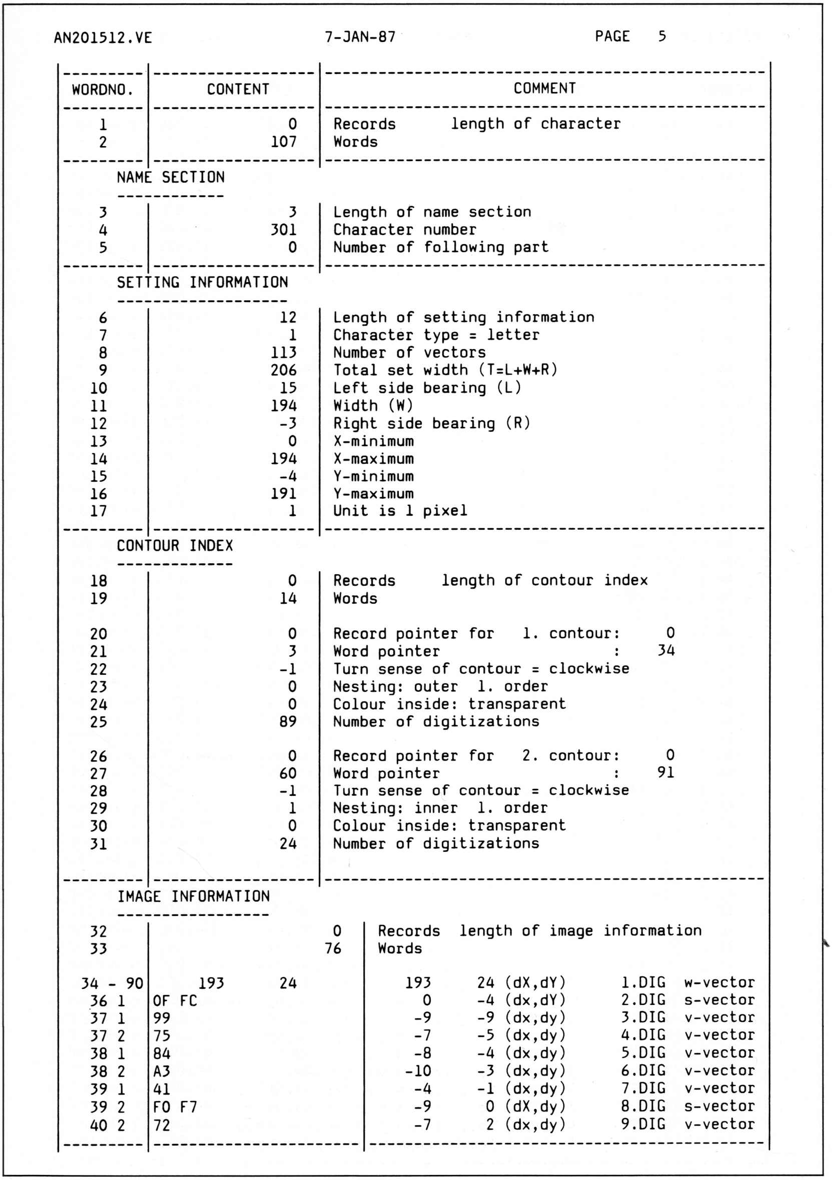
3. Example of a VE format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", with marks.
Subsequently the complete type font format is reproduced as a data list. The raster is 400 × 400 for the em.


V vector
S vector
L vector
W vector



```
AN201512.VE                      7-JAN-87                    PAGE   1

|---------|------------------|----------------------------------------------|
| WORDNO. |     CONTENT      |                   COMMENT                    |
|---------|------------------|----------------------------------------------|
|    1    |               484| Length of font header                        |
|---------|------------------|----------------------------------------------|
       NAME SECTION
       ------------
     2    |                55| Length of name section
     3    |               825| Number on URW list
  4 - 10  |  AN201512.VE     | File name (ASCII)

 11 - 49  |        URW-Antiqua 2000               | Font name (ASCII)
          |              normal
                                 |
    50    |                VE| Data format (ASCII)
 51 - 53  |            7  1 87| Production date:      7-Jan-87
 54 - 56  |            7  1 87| Date of last change:  7-Jan-87
 ---------|------------------|----------------------------------------------
       FONT INFORMATION
       ----------------
    57    |                19| Length of font information
    58    |                 1| Indicator for font
    59    |               135| Number of characters
    60    |               267| Cap height (in pixels)
    61    |               400| Body size (in pixels)
    62    |               187| x-height (in pixels)
    63    |               100| Distance: base line - lower body line(in pixels)
    64    |               400| Text line distance for setting (in pixels)
    65    |                40| Stem thickness (in pixels)
    66    |                 0| Angle of italisation (in 1/10 degree)
    67    |                 1| Optimum point size for setting (in p)
    68    |               174| Average character width (in pixels)
    69    |               375| X-extension of a pixel (in 1/1000mm)
    70    |               375| Y-extension of a pixel (in 1/1000mm)
    71    |               400| Em-resolution in X-direction (in pixels)
    72    |               400| Em-resolution in Y-direction (in pixels)
    73    |                 0| Scan indicator of image data
    74    |                 0| Width of printing window (in pixels)
    75    |                 0| Height of printing window (in pixels)
 ---------|------------------|----------------------------------------------
       HIERARCHY SECTION
       -----------------
    76    |                 1| No hierarchy section in this format
 ---------|------------------|----------------------------------------------
       CHARACTER INDEX
       ---------------
    77    |               408| Length of character index
    78    |                 6| LENGTH OF FONT IN PHYSICAL RECORDS
    79    |              1478| Last word of last record

    80    |               101| Character number:  1
    81    |                 1| Pointer to record containing start of character
    82    |               485| Word pointer to start of character

    83    |               102| Ch. no.: 2
    84    |                 1| Record pointer
    85    |               566| Word pointer

  86-  88|  103      1  680| No., record pointer, word pointer of ch.:    3
  89-  91|  104      1  779| No., record pointer, word pointer of ch.:    4
  92-  94|  105      1  872| No., record pointer, word pointer of ch.:    5
|---------|------------------|----------------------------------------------|
AN201512.VE                    7-JAN-87                    PAGE    2

|---------|-----------------|---------------------------------------------|
| WORDNO. |     CONTENT     |                   COMMENT                   |
|---------|-----------------|---------------------------------------------|
|  95-  97|  106     1  951 | No., record pointer, word pointer of ch.:  6 |
|  98- 100|  107     1 1022 | No., record pointer, word pointer of ch.:  7 |
| 101- 103|  108     1 1134 | No., record pointer, word pointer of ch.:  8 |
| 104- 106|  109     1 1220 | No., record pointer, word pointer of ch.:  9 |
| 107- 109|  110     1 1274 | No., record pointer, word pointer of ch.: 10 |
| 110- 112|  111     1 1334 | No., record pointer, word pointer of ch.: 11 |
| 113- 115|  112     1 1419 | No., record pointer, word pointer of ch.: 12 |
| 116- 118|  113     1 1480 | No., record pointer, word pointer of ch.: 13 |
| 119- 121|  114     1 1564 | No., record pointer, word pointer of ch.: 14 |
| 122- 124|  115     1 1641 | No., record pointer, word pointer of ch.: 15 |
| 125- 127|  116     1 1753 | No., record pointer, word pointer of ch.: 16 |
| 128- 130|  117     1 1845 | No., record pointer, word pointer of ch.: 17 |
| 131- 133|  118     1 1979 | No., record pointer, word pointer of ch.: 18 |
| 134- 136|  119     2   41 | No., record pointer, word pointer of ch.: 19 |
| 137- 139|  120     2  141 | No., record pointer, word pointer of ch.: 20 |
| 140- 142|  121     2  206 | No., record pointer, word pointer of ch.: 21 |
| 143- 145|  122     2  294 | No., record pointer, word pointer of ch.: 22 |
| 146- 148|  123     2  357 | No., record pointer, word pointer of ch.: 23 |
| 149- 151|  124     2  435 | No., record pointer, word pointer of ch.: 24 |
| 152- 154|  125     2  529 | No., record pointer, word pointer of ch.: 25 |
| 155- 157|  126     2  601 | No., record pointer, word pointer of ch.: 26 |
| 158- 160|  127     2  663 | No., record pointer, word pointer of ch.: 27 |
| 161- 163|  128     2  773 | No., record pointer, word pointer of ch.: 28 |
| 164- 166|  129     2  899 | No., record pointer, word pointer of ch.: 29 |
| 167- 169|  201     2 1039 | No., record pointer, word pointer of ch.: 30 |
| 170- 172|  208     2 1160 | No., record pointer, word pointer of ch.: 31 |
| 173- 175|  210     2 1283 | No., record pointer, word pointer of ch.: 32 |
| 176- 178|  237     2 1404 | No., record pointer, word pointer of ch.: 33 |
| 179- 181|  251     2 1556 | No., record pointer, word pointer of ch.: 34 |
| 182- 184|  301     2 1684 | No., record pointer, word pointer of ch.: 35 |
| 185- 187|  302     2 1791 | No., record pointer, word pointer of ch.: 36 |
| 188- 190|  303     2 1888 | No., record pointer, word pointer of ch.: 37 |
| 191- 193|  304     2 1969 | No., record pointer, word pointer of ch.: 38 |
| 194- 196|  305     3   23 | No., record pointer, word pointer of ch.: 39 |
| 197- 199|  306     3  115 | No., record pointer, word pointer of ch.: 40 |
| 200- 202|  307     3  192 | No., record pointer, word pointer of ch.: 41 |
| 203- 205|  308     3  330 | No., record pointer, word pointer of ch.: 42 |
| 206- 208|  309     3  410 | No., record pointer, word pointer of ch.: 43 |
| 209- 211|  310     3  480 | No., record pointer, word pointer of ch.: 44 |
| 212- 214|  311     3  565 | No., record pointer, word pointer of ch.: 45 |
| 215- 217|  312     3  642 | No., record pointer, word pointer of ch.: 46 |
| 218- 220|  313     3  693 | No., record pointer, word pointer of ch.: 47 |
| 221- 223|  314     3  798 | No., record pointer, word pointer of ch.: 48 |
| 224- 226|  315     3  874 | No., record pointer, word pointer of ch.: 49 |
| 227- 229|  316     3  964 | No., record pointer, word pointer of ch.: 50 |
| 230- 232|  317     3 1066 | No., record pointer, word pointer of ch.: 51 |
| 233- 235|  318     3 1167 | No., record pointer, word pointer of ch.: 52 |
| 236- 238|  319     3 1237 | No., record pointer, word pointer of ch.: 53 |
| 239- 241|  320     3 1322 | No., record pointer, word pointer of ch.: 54 |
| 242- 244|  321     3 1382 | No., record pointer, word pointer of ch.: 55 |
| 245- 247|  322     3 1453 | No., record pointer, word pointer of ch.: 56 |
| 248- 250|  323     3 1512 | No., record pointer, word pointer of ch.: 57 |
| 251- 253|  324     3 1584 | No., record pointer, word pointer of ch.: 58 |
| 254- 256|  325     3 1666 | No., record pointer, word pointer of ch.: 59 |
| 257- 259|  326     3 1750 | No., record pointer, word pointer of ch.: 60 |
| 260- 262|  327     3 1809 | No., record pointer, word pointer of ch.: 61 |
| 263- 265|  328     3 1956 | No., record pointer, word pointer of ch.: 62 |
| 266- 268|  329     4   46 | No., record pointer, word pointer of ch.: 63 |
| 269- 271|  330     4  162 | No., record pointer, word pointer of ch.: 64 |
|---------|-----------------|---------------------------------------------|
```



```
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|---------|-------------------|--------------------------------------------------|
 WORDNO.  |      CONTENT      |                   COMMENT
 ---------|-------------------|--------------------------------------------------
    1     |                  0| Records      length of character
    2     |                107| Words
 ---------|-------------------|--------------------------------------------------
       NAME SECTION
       ------------
    3     |                  3| Length of name section
    4     |                301| Character number
    5     |                  0| Number of following part
 ---------|-------------------|--------------------------------------------------
       SETTING INFORMATION
       -------------------
    6     |                 12| Length of setting information
    7     |                  1| Character type = letter
    8     |                113| Number of vectors
    9     |                206| Total set width (T=L+W+R)
   10     |                 15| Left side bearing (L)
   11     |                194| Width (W)
   12     |                 -3| Right side bearing (R)
   13     |                  0| X-minimum
   14     |                194| X-maximum
   15     |                 -4| Y-minimum
   16     |                191| Y-maximum
   17     |                  1| Unit is 1 pixel
 ---------|-------------------|--------------------------------------------------
       CONTOUR INDEX
       -------------
   18     |                  0| Records     length of contour index
   19     |                 14| Words
          |                   |
   20     |                  0| Record pointer for   1. contour:     0
   21     |                  3| Word pointer                   :    34
   22     |                 -1| Turn sense of contour = clockwise
   23     |                  0| Nesting: outer   1. order
   24     |                  0| Colour inside: transparent
   25     |                 89| Number of digitizations
          |                   |
   26     |                  0| Record pointer for   2. contour:     0
   27     |                 60| Word pointer                   :    91
   28     |                 -1| Turn sense of contour = clockwise
   29     |                  1| Nesting: inner   1. order
   30     |                  0| Colour inside: transparent
   31     |                 24| Number of digitizations
          |                   |
 ---------|-------------------|--------------------------------------------------
       IMAGE INFORMATION
       -----------------
   32     |                        0 | Records  length of image information
   33     |                       76 | Words
          |
 34 - 90  |     193       24         |     193      24 (dX,dY)      1.DIG  w-vector
  36 1    |0F FC                     |       0      -4 (dx,dY)      2.DIG  s-vector
  37 1    |99                        |      -9      -9 (dx,dy)      3.DIG  v-vector
  37 2    |75                        |      -7      -5 (dx,dy)      4.DIG  v-vector
  38 1    |84                        |      -8      -4 (dx,dy)      5.DIG  v-vector
  38 2    |A3                        |     -10      -3 (dx,dy)      6.DIG  v-vector
  39 1    |41                        |      -4      -1 (dx,dy)      7.DIG  v-vector
  39 2    |F0 F7                     |      -9       0 (dX,dy)      8.DIG  s-vector
  40 2    |72                        |      -7       2 (dx,dy)      9.DIG  v-vector
|---------|--------------------------|--------------------------------------------|
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 ---------  ----------------------  ------------------------------------------
  WORDNO.          CONTENT                            COMMENT
 ---------  ----------------------  ------------------------------------------
    41 1    64                         -6      4 (dx,dy)     10.DIG  v-vector
    41 2    55                         -5      5 (dx,dy)     11.DIG  v-vector
    42 1    6C                         -6     12 (dx,dy)     12.DIG  v-vector
    42 2    27                         -2      7 (dx,dy)     13.DIG  v-vector
    43 1    F0 FE                      -2      0 (dX,dy)     14.DIG  s-vector
    44 1    9A                         -9    -10 (dx,dy)     15.DIG  v-vector
    44 2    86                         -8     -6 (dx,dy)     16.DIG  v-vector
    45 1    85                         -8     -5 (dx,dy)     17.DIG  v-vector
    45 2    A5                        -10     -5 (dx,dy)     18.DIG  v-vector
    46 1    A4                        -10     -4 (dx,dy)     19.DIG  v-vector
    46 2    F1 E7                     -25     -1 (dX,dy)     20.DIG  s-vector
    47 2    81                         -8      1 (dx,dy)     21.DIG  v-vector
    48 1    E4 F2                     -14      4 (dX,dy)     22.DIG  s-vector
    49 1    74                         -7      4 (dx,dy)     23.DIG  v-vector
    49 2    AC                        -10     12 (dx,dy)     24.DIG  v-vector
    50 1    46                         -4      6 (dx,dy)     25.DIG  v-vector
    50 2    4D                         -4     13 (dx,dy)     26.DIG  v-vector
    51 1    0F 19                       0     25 (dx,dY)     27.DIG  s-vector
    52 1    39                          3      9 (dx,dy)     28.DIG  v-vector
    52 2    49                          4      9 (dx,dy)     29.DIG  v-vector
    53 1    67                          6      7 (dx,dy)     30.DIG  v-vector
    53 2    C8                         12      8 (dx,dy)     31.DIG  v-vector
    54 1    E6 0F                      15      6 (dX,dy)     32.DIG  s-vector
    55 1    E6 1A                      26      6 (dX,dy)     33.DIG  s-vector
    56 1    E2 0F                      15      2 (dX,dy)     34.DIG  s-vector
    57 1    E6 23                      35      6 (dX,dy)     35.DIG  s-vector
    58 1    24                          2      4 (dx,dy)     36.DIG  v-vector
    58 2    0F 0D                       0     13 (dx,dY)     37.DIG  s-vector
    59 2    2E 0F                      -2     15 (dx,dY)     38.DIG  s-vector
    60 2    5C                         -5     12 (dx,dy)     39.DIG  v-vector
    61 1    58                         -5      8 (dx,dy)     40.DIG  v-vector
    61 2    65                         -6      5 (dx,dy)     41.DIG  v-vector
    62 1    95                         -9      5 (dx,dy)     42.DIG  v-vector
    62 2    F1 EB                     -21      1 (dX,dy)     43.DIG  s-vector
    63 2    61                         -6     -1 (dx,dy)     44.DIG  v-vector
    64 1    73                         -7     -3 (dx,dy)     45.DIG  v-vector
    64 2    32                         -3     -2 (dx,dy)     46.DIG  v-vector
    65 1    22                         -2     -2 (dx,dy)     47.DIG  v-vector
    65 2    0F FE                       0     -2 (dx,dY)     48.DIG  s-vector
    66 2    12                          1     -2 (dx,dy)     49.DIG  v-vector
    67 1    34                          3     -4 (dx,dy)     50.DIG  v-vector
    67 2    46                          4     -6 (dx,dy)     51.DIG  v-vector
    68 1    14                          1     -4 (dx,dy)     52.DIG  v-vector
    68 2    0F F7                       0     -9 (dx,dY)     53.DIG  s-vector
    69 2    25                         -2     -5 (dx,dy)     54.DIG  v-vector
    70 1    45                         -4     -5 (dx,dy)     55.DIG  v-vector
    70 2    53                         -5     -3 (dx,dy)     56.DIG  v-vector
    71 1    52                         -5     -2 (dx,dy)     57.DIG  v-vector
    71 2    F0 F5                     -11      0 (dX,dy)     58.DIG  s-vector
    72 2    51                         -5      1 (dx,dy)     59.DIG  v-vector
    73 1    64                         -6      4 (dx,dy)     60.DIG  v-vector
    73 2    47                         -4      7 (dx,dy)     61.DIG  v-vector
    74 1    25                         -2      5 (dx,dy)     62.DIG  v-vector
    74 2    0F 0A                       0     10 (dx,dY)     63.DIG  s-vector
    75 2    27                          2      7 (dx,dy)     64.DIG  v-vector
    76 1    58                          5      8 (dx,dy)     65.DIG  v-vector
    76 2    56                          5      6 (dx,dy)     66.DIG  v-vector
    77 1    B7                         11      7 (dx,dy)     67.DIG  v-vector
    77 2    C4                         12      4 (dx,dy)     68.DIG  v-vector
 ---------  ----------------------  ------------------------------------------
```

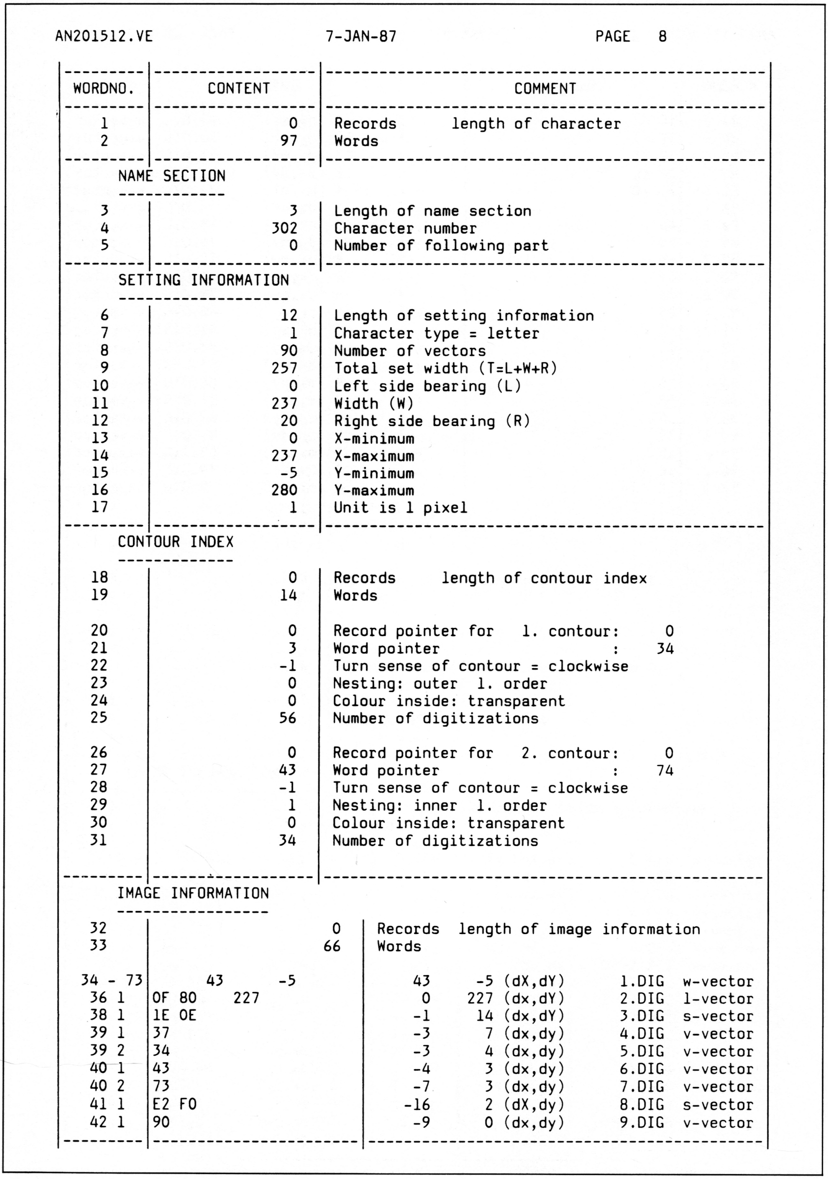

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|---------|-------------------|-----------------------------------------------|
| WORDNO. |      CONTENT      |                    COMMENT                    |
|---------|-------------------|-----------------------------------------------|
|    1    |                 0 | Records      length of character              |
|    2    |                97 | Words                                         |
|---------|-------------------|-----------------------------------------------|
|      NAME SECTION                                                           |
|      ------------                                                           |
|    3    |                 3 | Length of name section                        |
|    4    |               302 | Character number                              |
|    5    |                 0 | Number of following part                      |
|---------|-------------------|-----------------------------------------------|
|      SETTING INFORMATION                                                    |
|      -------------------                                                    |
|    6    |                12 | Length of setting information                 |
|    7    |                 1 | Character type = letter                       |
|    8    |                90 | Number of vectors                             |
|    9    |               257 | Total set width (T=L+W+R)                     |
|   10    |                 0 | Left side bearing (L)                         |
|   11    |               237 | Width (W)                                     |
|   12    |                20 | Right side bearing (R)                        |
|   13    |                 0 | X-minimum                                     |
|   14    |               237 | X-maximum                                     |
|   15    |                -5 | Y-minimum                                     |
|   16    |               280 | Y-maximum                                     |
|   17    |                 1 | Unit is 1 pixel                               |
|---------|-------------------|-----------------------------------------------|
|      CONTOUR INDEX                                                          |
|      -------------                                                          |
|   18    |                 0 | Records     length of contour index           |
|   19    |                14 | Words                                         |
|         |                   |                                               |
|   20    |                 0 | Record pointer for   1. contour:      0       |
|   21    |                 3 | Word pointer                  :      34       |
|   22    |                -1 | Turn sense of contour = clockwise             |
|   23    |                 0 | Nesting: outer  1. order                      |
|   24    |                 0 | Colour inside: transparent                    |
|   25    |                56 | Number of digitizations                       |
|         |                   |                                               |
|   26    |                 0 | Record pointer for   2. contour:      0       |
|   27    |                43 | Word pointer                  :      74       |
|   28    |                -1 | Turn sense of contour = clockwise             |
|   29    |                 1 | Nesting: inner  1. order                      |
|   30    |                 0 | Colour inside: transparent                    |
|   31    |                34 | Number of digitizations                       |
|         |                   |                                               |
|---------|-------------------|-----------------------------------------------|
|      IMAGE INFORMATION                                                      |
|      -----------------                                                      |
|   32    |                        0 | Records  length of image information   |
|   33    |                       66 | Words                                  |
|                                                                             |
|  34 - 73|      43        -5          43      -5 (dX,dY)      1.DIG  w-vector |
|  36 1   |OF 80    227                 0     227 (dx,dY)      2.DIG  l-vector |
|  38 1   |1E OE                       -1      14 (dx,dY)      3.DIG  s-vector |
|  39 1   |37                          -3       7 (dx,dy)      4.DIG  v-vector |
|  39 2   |34                          -3       4 (dx,dy)      5.DIG  v-vector |
|  40 1   |43                          -4       3 (dx,dy)      6.DIG  v-vector |
|  40 2   |73                          -7       3 (dx,dy)      7.DIG  v-vector |
|  41 1   |E2 FO                      -16       2 (dX,dy)      8.DIG  s-vector |
|  42 1   |90                          -9       0 (dx,dy)      9.DIG  v-vector |
|---------|----------------------|---------------------------------------------|
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 ---------  ----------------------  ------------------------------------------
  WORDNO.           CONTENT                          COMMENT
 ---------  ----------------------  ------------------------------------------
    83 1    5E F2                        5     -14 (dx,dY)       69.DIG  s-vector
    84 1    3E F1                        3     -15 (dx,dY)       70.DIG  s-vector
    85 1    1E EF                        1     -17 (dx,dY)       71.DIG  s-vector
    86 1    0F EE                        0     -18 (dx,dY)       72.DIG  s-vector
    87 1    2E F0                       -2     -16 (dx,dY)       73.DIG  s-vector
    88 1    2A                          -2     -10 (dx,dy)       74.DIG  v-vector
    88 2    4A                          -4     -10 (dx,dy)       75.DIG  v-vector
    89 1    58                          -5      -8 (dx,dy)       76.DIG  v-vector
    89 2    68                          -6      -8 (dx,dy)       77.DIG  v-vector
    90 1    77                          -7      -7 (dx,dy)       78.DIG  v-vector
    90 2    96                          -9      -6 (dx,dy)       79.DIG  v-vector
    91 1    D5                         -13      -5 (dx,dy)       80.DIG  v-vector
    91 2    F0 E7                      -25       0 (dX,dy)       81.DIG  s-vector
    92 2    C5                         -12       5 (dx,dy)       82.DIG  v-vector
    93 1    B7                         -11       7 (dx,dy)       83.DIG  v-vector
    93 2    88                          -8       8 (dx,dy)       84.DIG  v-vector
    94 1    57                          -5       7 (dx,dy)       85.DIG  v-vector
    94 2    38                          -3       8 (dx,dy)       86.DIG  v-vector
    95 1    39                          -3       9 (dx,dy)       87.DIG  v-vector
    95 2    28                          -2       8 (dx,dy)       88.DIG  v-vector
    96 1    1E 1E                       -1      30 (dx,dY)       89.DIG  s-vector
    97 1    0E 12                        0      18 (dx,dY)       90.DIG  s-vector

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```

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|---------|------------------|---------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                       |
|---------|------------------|---------------------------------------------------|
|    1    |                0 | Records      length of character                  |
|    2    |               81 | Words                                             |
|---------|------------------|---------------------------------------------------|
|      NAME SECTION                                                              |
|      ------------                                                              |
|    3    |                3 | Length of name section                            |
|    4    |              303 | Character number                                  |
|    5    |                0 | Number of following part                          |
|---------|------------------|---------------------------------------------------|
|      SETTING INFORMATION                                                       |
|      -------------------                                                       |
|    6    |               12 | Length of setting information                     |
|    7    |                1 | Character type = letter                           |
|    8    |               78 | Number of vectors                                 |
|    9    |              198 | Total set width (T=L+W+R)                         |
|   10    |               20 | Left side bearing (L)                             |
|   11    |              167 | Width (W)                                         |
|   12    |               11 | Right side bearing (R)                            |
|   13    |                0 | X-minimum                                         |
|   14    |              167 | X-maximum                                         |
|   15    |               -4 | Y-minimum                                         |
|   16    |              191 | Y-maximum                                         |
|   17    |                1 | Unit is 1 pixel                                   |
|---------|------------------|---------------------------------------------------|
|      CONTOUR INDEX                                                             |
|      -------------                                                             |
|   18    |                0 | Records     length of contour index               |
|   19    |                8 | Words                                             |
|         |                  |                                                   |
|   20    |                0 | Record pointer for    1. contour:     0           |
|   21    |                3 | Word pointer                    :    28           |
|   22    |               -1 | Turn sense of contour = clockwise                 |
|   23    |                0 | Nesting: outer  1. order                          |
|   24    |                0 | Colour inside: transparent                        |
|   25    |               78 | Number of digitizations                           |
|         |                  |                                                   |
|---------|------------------|---------------------------------------------------|
|      IMAGE INFORMATION                                                         |
|      -----------------                                                         |
|   26    |                        0 | Records  length of image information      |
|   27    |                       56 | Words                                     |
|                                   |                                           |
|  28 - 81|     164      31          |      164     31 (dX,dY)     1.DIG  w-vector |
|  30 1   |OF FE                     |        0     -2 (dx,dY)     2.DIG  s-vector |
|  31 1   |88                        |       -8     -8 (dx,dy)     3.DIG  v-vector |
|  31 2   |97                        |       -9     -7 (dx,dy)     4.DIG  v-vector |
|  32 1   |A6                        |      -10     -6 (dx,dy)     5.DIG  v-vector |
|  32 2   |B5                        |      -11     -5 (dx,dy)     6.DIG  v-vector |
|  33 1   |C4                        |      -12     -4 (dx,dy)     7.DIG  v-vector |
|  33 2   |E2 F2                     |      -14     -2 (dX,dy)     8.DIG  s-vector |
|  34 2   |FO E3                     |      -29      0 (dX,dy)     9.DIG  s-vector |
|  35 2   |E4 F1                     |      -15      4 (dX,dy)    10.DIG  s-vector |
|  36 2   |E8 F2                     |      -14      8 (dX,dy)    11.DIG  s-vector |
|  37 2   |DA                        |      -13     10 (dx,dy)    12.DIG  v-vector |
|  38 1   |77                        |       -7      7 (dx,dy)    13.DIG  v-vector |
|  38 2   |58                        |       -5      8 (dx,dy)    14.DIG  v-vector |
|  39 1   |AE 12                     |      -10     18 (dx,dY)    15.DIG  s-vector |
|  40 1   |5E 15                     |       -5     21 (dx,dY)    16.DIG  s-vector |
|---------|--------------------------|-------------------------------------------|
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 ---------  ----------------------  ----------------------------------------------
 WORDNO.           CONTENT                             COMMENT
 ---------  ----------------------  ----------------------------------------------
    41 1   |1B                    |     -1    11 (dx,dy)      17.DIG   v-vector
    41 2   |0F  14                |      0    20 (dx,dY)      18.DIG   s-vector
    42 2   |1B                    |      1    11 (dx,dy)      19.DIG   v-vector
    43 1   |5E  13                |      5    19 (dx,dY)      20.DIG   s-vector
    44 1   |6E  0F                |      6    15 (dx,dY)      21.DIG   s-vector
    45 1   |AD                    |     10    13 (dx,dy)      22.DIG   v-vector
    45 2   |77                    |      7     7 (dx,dy)      23.DIG   v-vector
    46 1   |76                    |      7     6 (dx,dy)      24.DIG   v-vector
    46 2   |85                    |      8     5 (dx,dy)      25.DIG   v-vector
    47 1   |83                    |      8     3 (dx,dy)      26.DIG   v-vector
    47 2   |E6  12                |     18     6 (dX,dy)      27.DIG   s-vector
    48 2   |A1                    |     10     1 (dx,dy)      28.DIG   v-vector
    49 1   |F0  1A                |     26     0 (dX,dy)      29.DIG   s-vector
    50 1   |E3  0F                |     15    -3 (dX,dy)      30.DIG   s-vector
    51 1   |E4  0E                |     14    -4 (dX,dy)      31.DIG   s-vector
    52 1   |C7                    |     12    -7 (dx,dy)      32.DIG   v-vector
    52 2   |87                    |      8    -7 (dx,dy)      33.DIG   v-vector
    53 1   |78                    |      7    -8 (dx,dy)      34.DIG   v-vector
    53 2   |27                    |      2    -7 (dx,dy)      35.DIG   v-vector
    54 1   |14                    |      1    -4 (dx,dy)      36.DIG   v-vector
    54 2   |0F  F3                |      0   -13 (dx,dY)      37.DIG   s-vector
    55 2   |25                    |     -2    -5 (dx,dy)      38.DIG   v-vector
    56 1   |34                    |     -3    -4 (dx,dy)      39.DIG   v-vector
    56 2   |43                    |     -4    -3 (dx,dy)      40.DIG   v-vector
    57 1   |42                    |     -4    -2 (dx,dy)      41.DIG   v-vector
    57 2   |52                    |     -5    -2 (dx,dy)      42.DIG   v-vector
    58 1   |F0  FA                |     -6     0 (dX,dy)      43.DIG   s-vector
    59 1   |A1                    |    -10     1 (dx,dy)      44.DIG   v-vector
    59 2   |65                    |     -6     5 (dx,dy)      45.DIG   v-vector
    60 1   |46                    |     -4     6 (dx,dy)      46.DIG   v-vector
    60 2   |14                    |     -1     4 (dx,dy)      47.DIG   v-vector
    61 1   |0F  07                |      0     7 (dx,dY)      48.DIG   s-vector
    62 1   |14                    |      1     4 (dx,dy)      49.DIG   v-vector
    62 2   |46                    |      4     6 (dx,dy)      50.DIG   v-vector
    63 1   |44                    |      4     4 (dx,dy)      51.DIG   v-vector
    63 2   |0F  07                |      0     7 (dx,dY)      52.DIG   s-vector
    64 2   |12                    |     -1     2 (dx,dy)      53.DIG   v-vector
    65 1   |76                    |     -7     6 (dx,dy)      54.DIG   v-vector
    65 2   |A4                    |    -10     4 (dx,dy)      55.DIG   v-vector
    66 1   |F0  E7                |    -25     0 (dX,dy)      56.DIG   s-vector
    67 1   |B3                    |    -11    -3 (dx,dy)      57.DIG   v-vector
    67 2   |A6                    |    -10    -6 (dx,dy)      58.DIG   v-vector
    68 1   |76                    |     -7    -6 (dx,dy)      59.DIG   v-vector
    68 2   |8B                    |     -8   -11 (dx,dy)      60.DIG   v-vector
    69 1   |6E  F1                |     -6   -15 (dx,dY)      61.DIG   s-vector
    70 1   |4E  EC                |     -4   -20 (dx,dY)      62.DIG   s-vector
    71 1   |0F  D9                |      0   -39 (dx,dY)      63.DIG   s-vector
    72 1   |4E  F0                |      4   -16 (dx,dY)      64.DIG   s-vector
    73 1   |6E  F0                |      6   -16 (dx,dY)      65.DIG   s-vector
    74 1   |57                    |      5    -7 (dx,dy)      66.DIG   v-vector
    74 2   |66                    |      6    -6 (dx,dy)      67.DIG   v-vector
    75 1   |87                    |      8    -7 (dx,dy)      68.DIG   v-vector
    75 2   |A5                    |     10    -5 (dx,dy)      69.DIG   v-vector
    76 1   |C4                    |     12    -4 (dx,dy)      70.DIG   v-vector
    76 2   |F0  15                |     21     0 (dX,dy)      71.DIG   s-vector
    77 2   |81                    |      8     1 (dx,dy)      72.DIG   v-vector
    78 1   |E5  10                |     16     5 (dX,dy)      73.DIG   s-vector
    79 1   |85                    |      8     5 (dx,dy)      74.DIG   v-vector
    79 2   |75                    |      7     5 (dx,dy)      75.DIG   v-vector
 ---------  ----------------------  ----------------------------------------------
```

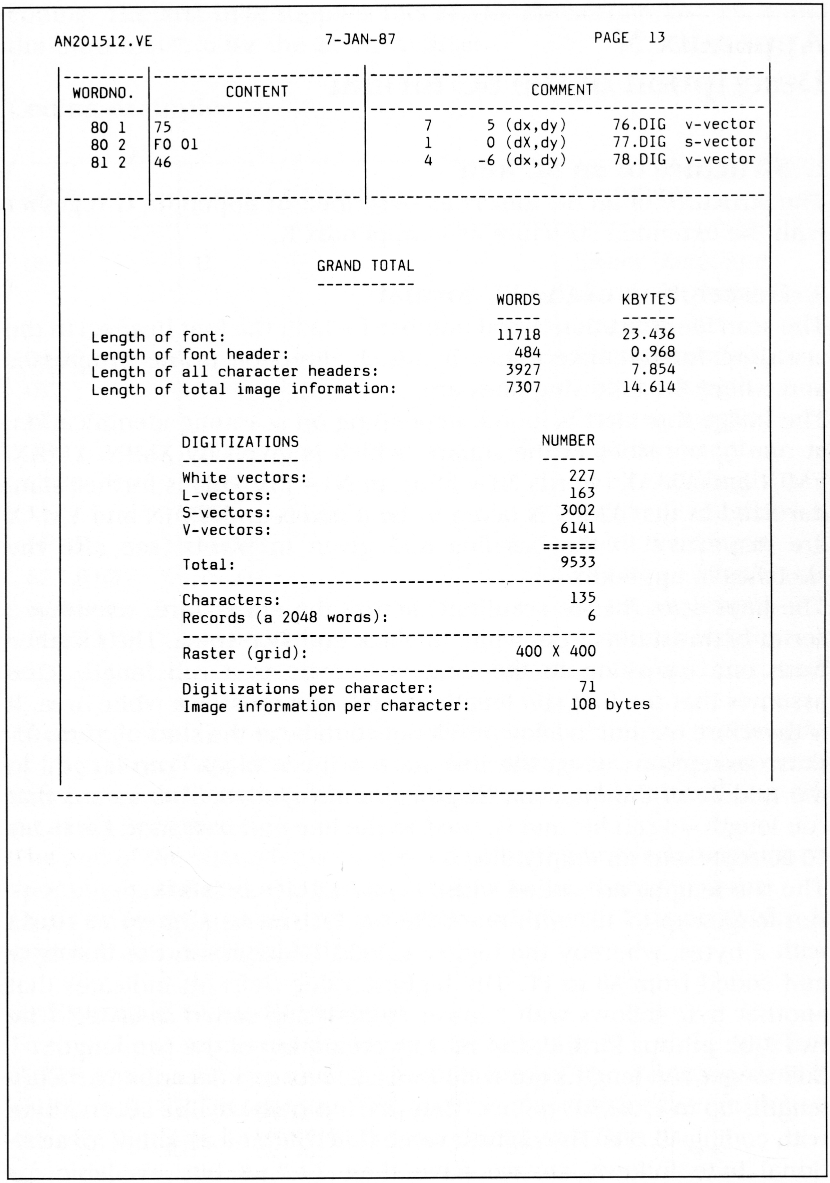

```
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  |---------|-------------------------|-------------------------------------------|
  | WORDNO. |         CONTENT         |                  COMMENT                  |
  |---------|-------------------------|-------------------------------------------|
  |   80 1  |75                       |         7     5 (dx,dy)     76.DIG  v-vector |
  |   80 2  |F0 01                    |         1     0 (dX,dy)     77.DIG  s-vector |
  |   81 2  |46                       |         4    -6 (dx,dy)     78.DIG  v-vector |
  |         |                         |                                           |
  |---------|-------------------------|-------------------------------------------|
  |
  |                               GRAND TOTAL
  |                               -----------
  |                                                    WORDS        KBYTES
  |                                                    -----        ------
  |    Length of font:                                 11718        23.436
  |    Length of font header:                            484         0.968
  |    Length of all character headers:                 3927         7.854
  |    Length of total image information:               7307        14.614
  |
  |             DIGITIZATIONS                                 NUMBER
  |             -------------                                 ------
  |             White vectors:                                   227
  |             L-vectors:                                       163
  |             S-vectors:                                      3002
  |             V-vectors:                                      6141
  |                                                           ======
  |             Total:                                          9533
  |             ------------------------------------------------------
  |             Characters:                                      135
  |             Records (a 2048 words):                            6
  |             ------------------------------------------------------
  |             Raster (grid):                             400 X 400
  |             ------------------------------------------------------
  |             Digitizations per character:                      71
  |             Image information per character:                 108 bytes
  |
  --------------------------------------------------------------------------------
```

Appendix N
Description of the SC format

1. Structure of an SC font

The structure of an SC font is as described in appendix G together with the extended structure as in appendix K.

2. Description of the SC format

The scan identification (word number I + 18 in the font header) in the **scanline format** determines in which direction a line progresses and where the following lines are.

The image line start is found, depending on scanning identification, at one of the sides of the square, which is given by XMIN, XMAX, YMIN and YMAX (words N1 + 10 up to N1 + 13). This is further standardized in that XMIN is taken to be 0 pixels and YMIN and YMAX are respective to the baseline and given in pixels (see also the sketches in appendix K).

The lines scan (hence scanlines) across the em square, scanning a series of transitions from white to black and vice versa. The distance from one transition to the next is known as a run length. One assumes that the first run length of each line crosses a white area. It is therefore natural to allow run length 0 to be at the start of a line for those exceptions when the line starts with a "black" run length. In the middle of the line, run lengths are always $\neq 0$. This means that run length = 0 can be, and is, used as the line end indicator, i.e. bytes 00 00 represent an empty line.

The run lengths are coded with 7, 14 or 22 bits as follows:

run length up to 127 with one byte 00...7F; run lengths up to 16,383 with 2 bytes, whereby the higher valued 7 bits are in the first byte and coded from 80 to FF. The highest value (left) bit indicates that another byte follows with 7 lower valued bits, coded as 00...7F. The two 7 bit groups form the 14 bit representation of the run length.

Still longer run lengths are coded with 22 bits and describe in theory lengths up to 4,194,303 points. They are indicated by the second byte with coding 80...FF. The highest value (left) bit indicates that an additional byte follows, i.e. we have then 7 + 7 + 8 bits available for coding. The first byte supplies bits 21...15, the second bits 14...8 and the third bits 7...0 for the 22 bit coding.

Coding examples

Bytes	Coded run length	Comment
00	0	Either black line start (non-white) or scanline end
00 00	0	Empty scanline
01	1	7 bit run length
0F	15	7 bit run length
7F	127	7 bit run length
81 00	128	14 bit run length
81 7F	255	14 bit run length
FF 7F	16,383	14 bit run length
80 C0 00	16,384	22 bit run length
82 80 00	65,538	22 bit run length
FF FF FE	4,194,303	22 bit run length

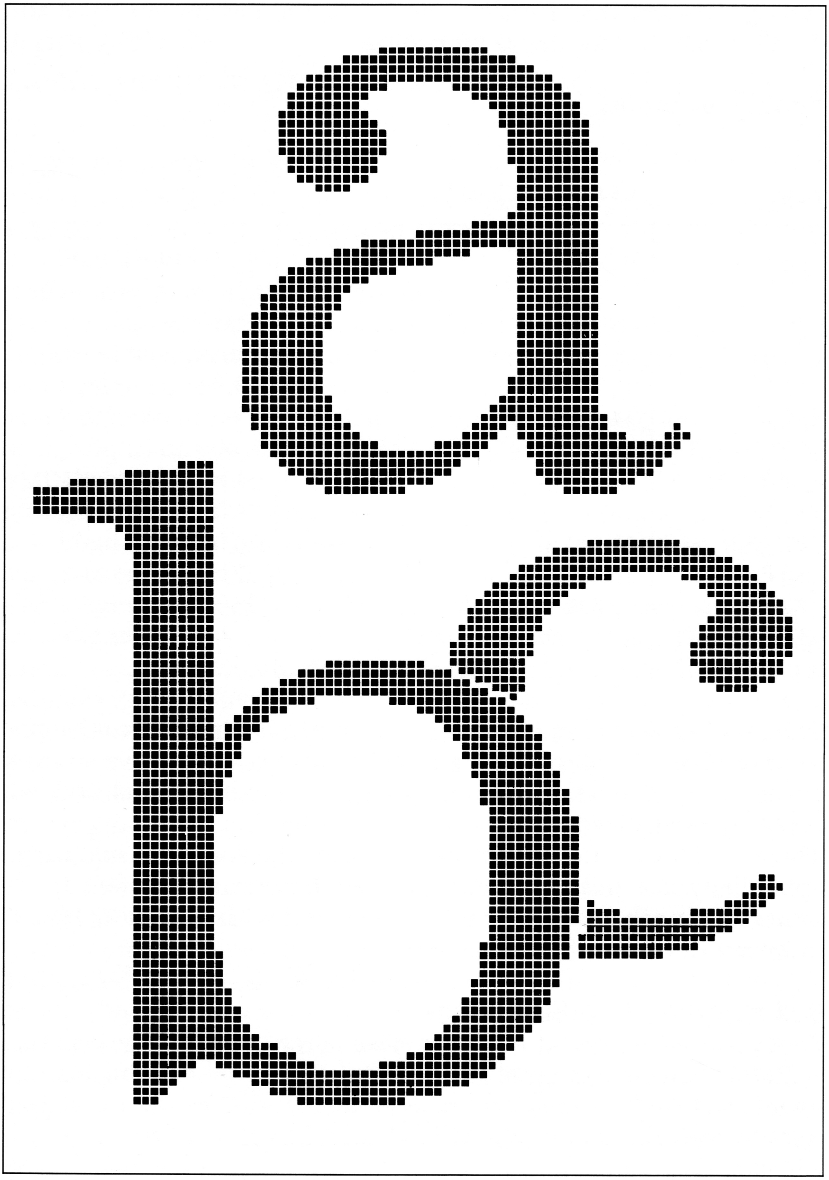
The number of line repetitions is written just behind the run lengths of a scanline, if applicable. As a scanline always has to have an even number of run lengths, this notation gives an odd number and can be easily recognized.

The end of the character is controlled using the line index and correspondingly, the end of a font is checked in the character index.

One run length, no matter whether coded with 7, 14 or 22 bits, is counted as one digitization.

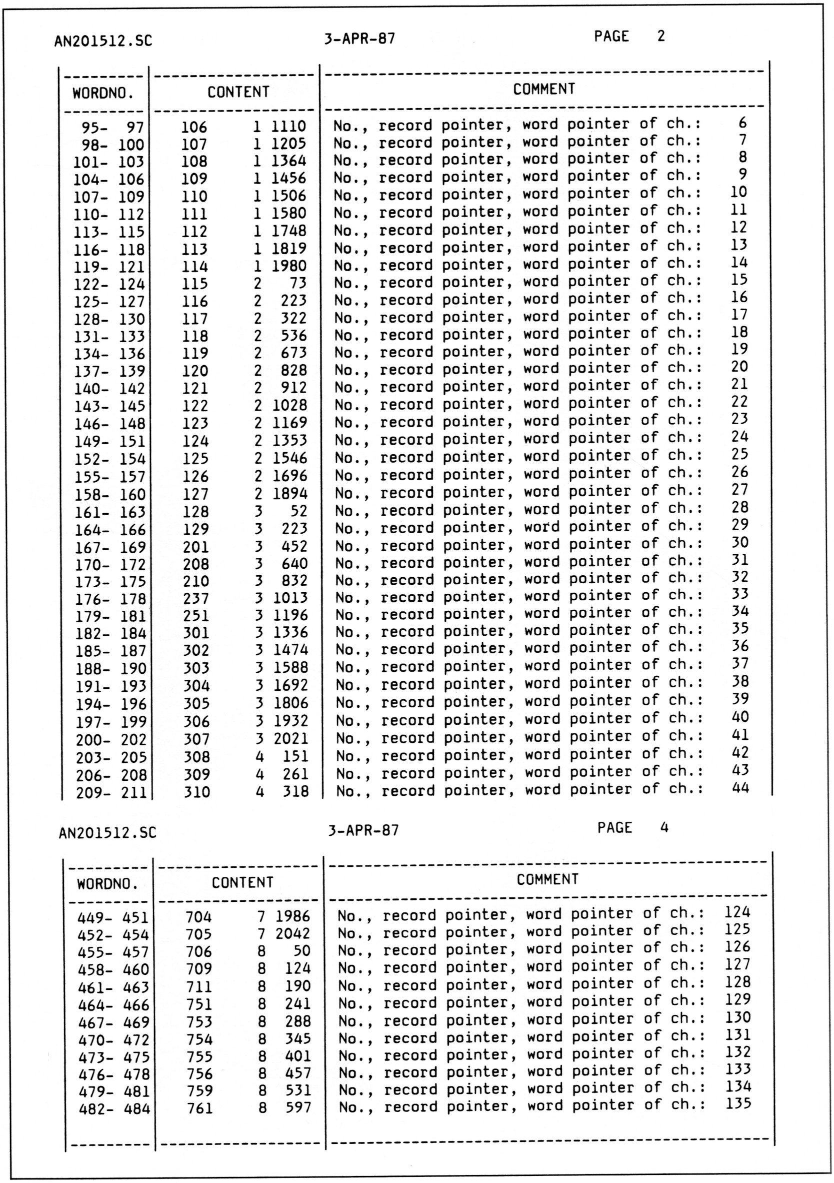
3. Example of an SC format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", as a raster image. The scanning identification is 21 (CRT machines). The raster is 100 × 100 for the em. Subsequently the type font format is reproduced as a data list.



```
     AN201512.SC                  3-APR-87                  PAGE   1

    |---------|------------------|---------------------------------------------|
    | WORDNO. |     CONTENT      |                  COMMENT                    |
    |---------|------------------|---------------------------------------------|
    |    1    |               484| Length of font header
    |---------|------------------|---------------------------------------------|
            NAME SECTION
            ------------
         2  |                55 | Length of name section
         3  |               825 | Number on URW list
      4 - 10|   AN201512.SC     | File name (ASCII)
            |                   |
     11 - 49|         URW-Antiqua 2000               | Font name (ASCII)
            |              normal
            |                   |
        50  |                SC | Data format (ASCII)
     51 - 53|          20  3 87 | Production date:       20-Mar-87
     54 - 56|           3  4 87 | Date of last change:  3-Apr-87
    ---------|------------------|---------------------------------------------
            FONT INFORMATION
            ----------------
        57  |                19 | Length of font information
        58  |                 1 | Indicator for font
        59  |               135 | Number of characters
        60  |                67 | Cap height (in pixels)
        61  |               100 | Body size (in pixels)
        62  |                47 | x-height (in pixels)
        63  |                25 | Distance: base line - lower body line(in pixels)
        64  |               100 | Text line distance for setting (in pixels)
        65  |                10 | Stem thickness (in pixels)
        66  |                 0 | Angle of italisation (in 1/10 degree)
        67  |                12 | Optimum point size for setting (in p)
        68  |                43 | Average character width (in pixels)
        69  |              1500 | X-extension of a pixel (in 1/1000mm)
        70  |              1500 | Y-extension of a pixel (in 1/1000mm)
        71  |               100 | Em-resolution in X-direction (in pixels)
        72  |               100 | Em-resolution in Y-direction (in pixels)
        73  |                21 | Scan indicator of image data
        74  |                 0 | Width of printing window (in pixels)
        75  |                 0 | Height of printing window (in pixels)
    ---------|------------------|---------------------------------------------
            HIERARCHY SECTION
            -----------------
        76  |                 1 | No hierarchy section in this format
    ---------|------------------|---------------------------------------------
            CHARACTER INDEX
            ---------------
        77  |               408 | Length of character index
        78  |                 8 | LENGTH OF FONT IN PHYSICAL RECORDS
        79  |               647 | Last word of last record
            |                   |
        80  |               101 | Character number:  1
        81  |                 1 | Pointer to record containing start of character
        82  |               485 | Word pointer to start of character
            |                   |
        83  |               102 | Ch. no.: 2
        84  |                 1 | Record pointer
        85  |               649 | Word pointer
            |                   |
     86-  88|  103      1  759  | No., record pointer, word pointer of ch.:    3
     89-  91|  104      1  901  | No., record pointer, word pointer of ch.:    4
     92-  94|  105      1 1003  | No., record pointer, word pointer of ch.:    5
    |---------|------------------|---------------------------------------------|
```



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AN201512.SC                           3-APR-87                        PAGE    2

|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
|  95-  97|  106       1 1110| No., record pointer, word pointer of ch.:    6|
|  98- 100|  107       1 1205| No., record pointer, word pointer of ch.:    7|
| 101- 103|  108       1 1364| No., record pointer, word pointer of ch.:    8|
| 104- 106|  109       1 1456| No., record pointer, word pointer of ch.:    9|
| 107- 109|  110       1 1506| No., record pointer, word pointer of ch.:   10|
| 110- 112|  111       1 1580| No., record pointer, word pointer of ch.:   11|
| 113- 115|  112       1 1748| No., record pointer, word pointer of ch.:   12|
| 116- 118|  113       1 1819| No., record pointer, word pointer of ch.:   13|
| 119- 121|  114       1 1980| No., record pointer, word pointer of ch.:   14|
| 122- 124|  115       2   73| No., record pointer, word pointer of ch.:   15|
| 125- 127|  116       2  223| No., record pointer, word pointer of ch.:   16|
| 128- 130|  117       2  322| No., record pointer, word pointer of ch.:   17|
| 131- 133|  118       2  536| No., record pointer, word pointer of ch.:   18|
| 134- 136|  119       2  673| No., record pointer, word pointer of ch.:   19|
| 137- 139|  120       2  828| No., record pointer, word pointer of ch.:   20|
| 140- 142|  121       2  912| No., record pointer, word pointer of ch.:   21|
| 143- 145|  122       2 1028| No., record pointer, word pointer of ch.:   22|
| 146- 148|  123       2 1169| No., record pointer, word pointer of ch.:   23|
| 149- 151|  124       2 1353| No., record pointer, word pointer of ch.:   24|
| 152- 154|  125       2 1546| No., record pointer, word pointer of ch.:   25|
| 155- 157|  126       2 1696| No., record pointer, word pointer of ch.:   26|
| 158- 160|  127       2 1894| No., record pointer, word pointer of ch.:   27|
| 161- 163|  128       3   52| No., record pointer, word pointer of ch.:   28|
| 164- 166|  129       3  223| No., record pointer, word pointer of ch.:   29|
| 167- 169|  201       3  452| No., record pointer, word pointer of ch.:   30|
| 170- 172|  208       3  640| No., record pointer, word pointer of ch.:   31|
| 173- 175|  210       3  832| No., record pointer, word pointer of ch.:   32|
| 176- 178|  237       3 1013| No., record pointer, word pointer of ch.:   33|
| 179- 181|  251       3 1196| No., record pointer, word pointer of ch.:   34|
| 182- 184|  301       3 1336| No., record pointer, word pointer of ch.:   35|
| 185- 187|  302       3 1474| No., record pointer, word pointer of ch.:   36|
| 188- 190|  303       3 1588| No., record pointer, word pointer of ch.:   37|
| 191- 193|  304       3 1692| No., record pointer, word pointer of ch.:   38|
| 194- 196|  305       3 1806| No., record pointer, word pointer of ch.:   39|
| 197- 199|  306       3 1932| No., record pointer, word pointer of ch.:   40|
| 200- 202|  307       3 2021| No., record pointer, word pointer of ch.:   41|
| 203- 205|  308       4  151| No., record pointer, word pointer of ch.:   42|
| 206- 208|  309       4  261| No., record pointer, word pointer of ch.:   43|
| 209- 211|  310       4  318| No., record pointer, word pointer of ch.:   44|

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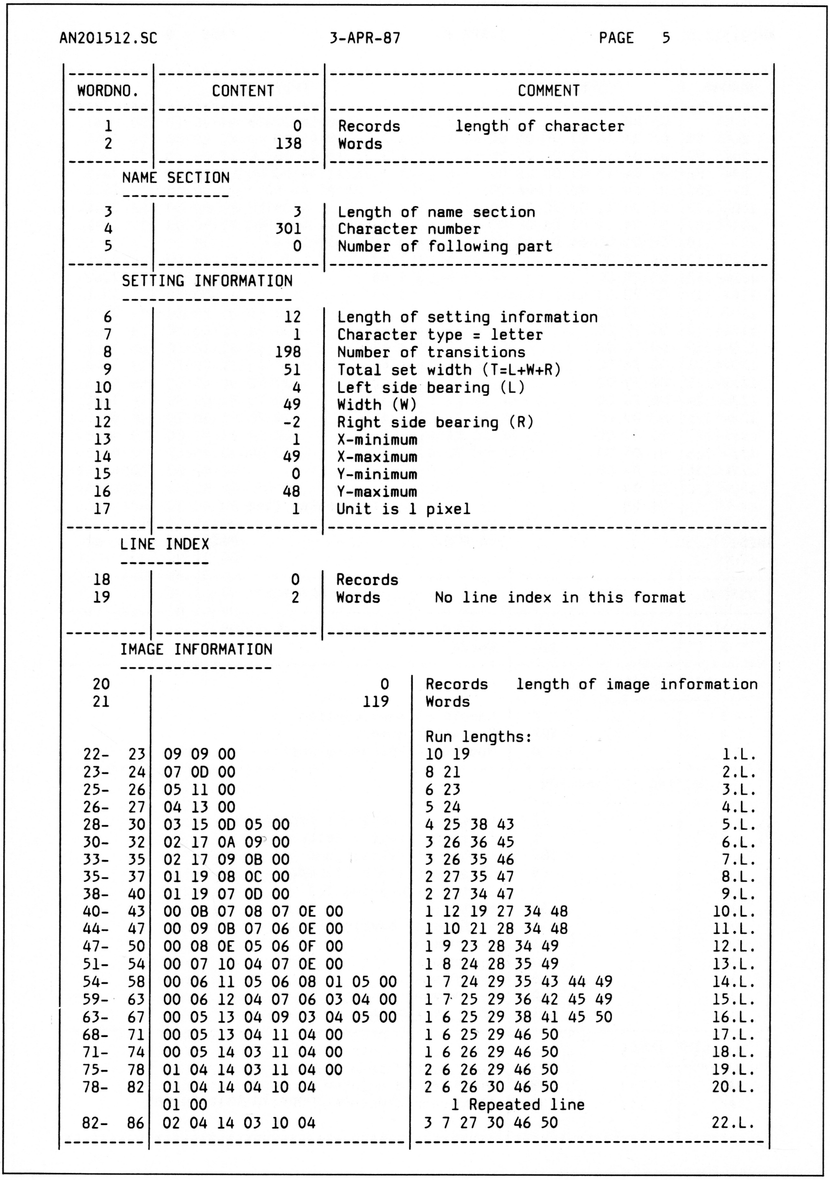
|---------|------------------|-----------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                    |
|---------|------------------|-----------------------------------------------|
| 449- 451|  704       7 1986| No., record pointer, word pointer of ch.:  124|
| 452- 454|  705       7 2042| No., record pointer, word pointer of ch.:  125|
| 455- 457|  706       8   50| No., record pointer, word pointer of ch.:  126|
| 458- 460|  709       8  124| No., record pointer, word pointer of ch.:  127|
| 461- 463|  711       8  190| No., record pointer, word pointer of ch.:  128|
| 464- 466|  751       8  241| No., record pointer, word pointer of ch.:  129|
| 467- 469|  753       8  288| No., record pointer, word pointer of ch.:  130|
| 470- 472|  754       8  345| No., record pointer, word pointer of ch.:  131|
| 473- 475|  755       8  401| No., record pointer, word pointer of ch.:  132|
| 476- 478|  756       8  457| No., record pointer, word pointer of ch.:  133|
| 479- 481|  759       8  531| No., record pointer, word pointer of ch.:  134|
| 482- 484|  761       8  597| No., record pointer, word pointer of ch.:  135|
|         |                  |                                               |
|---------|------------------|-----------------------------------------------|
```



```
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|---------|------------------|--------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|     1   |                0 | Records      length of character                 |
|     2   |              138 | Words                                            |
|---------|------------------|--------------------------------------------------|
|     NAME SECTION                                                             |
|     ------------                                                             |
|     3   |                3 | Length of name section                           |
|     4   |              301 | Character number                                 |
|     5   |                0 | Number of following part                         |
|---------|------------------|--------------------------------------------------|
|     SETTING INFORMATION                                                      |
|     -------------------                                                      |
|     6   |               12 | Length of setting information                    |
|     7   |                1 | Character type = letter                          |
|     8   |              198 | Number of transitions                            |
|     9   |               51 | Total set width (T=L+W+R)                        |
|    10   |                4 | Left side bearing (L)                            |
|    11   |               49 | Width (W)                                        |
|    12   |               -2 | Right side bearing (R)                           |
|    13   |                1 | X-minimum                                        |
|    14   |               49 | X-maximum                                        |
|    15   |                0 | Y-minimum                                        |
|    16   |               48 | Y-maximum                                        |
|    17   |                1 | Unit is 1 pixel                                  |
|---------|------------------|--------------------------------------------------|
|     LINE INDEX                                                               |
|     ----------                                                               |
|    18   |                0 | Records                                          |
|    19   |                2 | Words      No line index in this format          |
|         |                  |                                                  |
|---------|------------------|--------------------------------------------------|
|     IMAGE INFORMATION                                                        |
|     -----------------                                                        |
|    20   |                          0 | Records   length of image information    |
|    21   |                        119 | Words                                    |
|         |                            |                                          |
|         |                            | Run lengths:                             |
|  22-  23| 09 09 00                   | 10 19                               1.L. |
|  23-  24| 07 0D 00                   | 8 21                                2.L. |
|  25-  26| 05 11 00                   | 6 23                                3.L. |
|  26-  27| 04 13 00                   | 5 24                                4.L. |
|  28-  30| 03 15 0D 05 00             | 4 25 38 43                          5.L. |
|  30-  32| 02 17 0A 09 00             | 3 26 36 45                          6.L. |
|  33-  35| 02 17 09 0B 00             | 3 26 35 46                          7.L. |
|  35-  37| 01 19 08 0C 00             | 2 27 35 47                          8.L. |
|  38-  40| 01 19 07 0D 00             | 2 27 34 47                          9.L. |
|  40-  43| 00 0B 07 08 07 0E 00       | 1 12 19 27 34 48                   10.L. |
|  44-  47| 00 09 0B 07 06 0E 00       | 1 10 21 28 34 48                   11.L. |
|  47-  50| 00 08 0E 05 06 0F 00       | 1 9 23 28 34 49                    12.L. |
|  51-  54| 00 07 10 04 07 0E 00       | 1 8 24 28 35 49                    13.L. |
|  54-  58| 00 06 11 05 06 08 01 05 00 | 1 7 24 29 35 43 44 49              14.L. |
|  59-  63| 00 06 12 04 07 06 03 04 00 | 1 7 25 29 36 42 45 49              15.L. |
|  63-  67| 00 05 13 04 09 03 04 05 00 | 1 6 25 29 38 41 45 50              16.L. |
|  68-  71| 00 05 13 04 11 04 00       | 1 6 25 29 46 50                    17.L. |
|  71-  74| 00 05 14 03 11 04 00       | 1 6 26 29 46 50                    18.L. |
|  75-  78| 01 04 14 03 11 04 00       | 2 6 26 29 46 50                    19.L. |
|  78-  82| 01 04 14 04 10 04          | 2 6 26 30 46 50                    20.L. |
|         | 01 00                      |    1 Repeated line                       |
|  82-  86| 02 04 14 03 10 04          | 3 7 27 30 46 50                    22.L. |
|---------|----------------------------|------------------------------------------|
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|---------|-----------------------------|---------------------------------------|
| WORDNO. |           CONTENT           |                COMMENT                |
|---------|-----------------------------|---------------------------------------|
|         | 01 00                       |    1 Repeated line                    |
|  86-  89| 03 03 14 03 0F 05 00        | 4 7 27 30 45 50                 24.L. |
|  90-  93| 04 03 13 03 0F 05 00        | 5 8 27 30 45 50                 25.L. |
|  93-  96| 04 04 13 03 0D 06 00        | 5 9 28 31 44 50                 26.L. |
|  97- 100| 05 04 12 03 0D 06 00        | 6 10 28 31 44 50                27.L. |
| 100- 103| 06 04 11 03 0C 06 00        | 7 11 28 31 43 49                28.L. |
| 104- 107| 07 04 10 03 0A 08 00        | 8 12 28 31 41 49                29.L. |
| 107- 110| 08 05 0E 04 05 0C 00        | 9 14 28 32 37 49                30.L. |
| 111- 112| 06 29 00                    | 7 48                            31.L. |
| 112- 113| 04 2B 00                    | 5 48                            32.L. |
| 114- 115| 02 2C 00                    | 3 47                            33.L. |
| 115- 116| 01 2D 00                    | 2 47                            34.L. |
| 117- 118| 01 2C 00                    | 2 46                            35.L. |
| 118- 119| 00 2C 00                    | 1 45                            36.L. |
| 120- 121| 00 2B 00                    | 1 44                            37.L. |
| 121- 122| 00 29 00                    | 1 42                            38.L. |
| 123- 124| 00 26 00                    | 1 39                            39.L. |
| 124- 125| 00 09 00                    | 1 10                            40.L. |
| 126- 127| 00 07 00                    | 1 8                             41.L. |
| 127- 128| 01 06 00                    | 2 8                             42.L. |
| 129- 130| 01 05 00                    | 2 7                             43.L. |
| 130- 132| 02 04                       | 3 7                             44.L. |
|         | 01 00                       |    1 Repeated line                    |

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|---------|------------------|-------------------------------------------|
| WORDNO. |     CONTENT      |                 COMMENT                   |
|---------|------------------|-------------------------------------------|
|    1    |                0 | Records      length of character          |
|    2    |              114 | Words                                     |
|---------|------------------|-------------------------------------------|
|      NAME SECTION
|      ------------
|    3    |                3 | Length of name section                    |
|    4    |              302 | Character number                          |
|    5    |                0 | Number of following part                  |
|---------|------------------|-------------------------------------------|
|      SETTING INFORMATION
|      -------------------
|    6    |               12 | Length of setting information             |
|    7    |                1 | Character type = letter                   |
|    8    |              180 | Number of transitions                     |
|    9    |               65 | Total set width (T=L+W+R)                 |
|   10    |                0 | Left side bearing (L)                     |
|   11    |               60 | Width (W)                                 |
|   12    |                5 | Right side bearing (R)                    |
|   13    |                1 | X-minimum                                 |
|   14    |               60 | X-maximum                                 |
|   15    |                0 | Y-minimum                                 |
|   16    |               70 | Y-maximum                                 |
|   17    |                1 | Unit is 1 pixel                           |
|---------|------------------|-------------------------------------------|
|      LINE INDEX
|      ----------
|   18    |                0 | Records                                   |
|   19    |                2 | Words      No line index in this format   |
|         |                  |                                           |
|---------|------------------|-------------------------------------------|
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|---------|-----------------------------|--------------------------------------|
| WORDNO. |           CONTENT           |               COMMENT                |
|---------|-----------------------------|--------------------------------------|
|  56-  58| 01 06 24 03 00              | 2 8 44 47                      27.L. |
|  58-  60| 01 05 25 04 00              | 2 7 44 48                      28.L. |
|  61-  63| 01 05 26 03 00              | 2 7 45 48                      29.L. |
|  63-  66| 00 05 27 04                 | 1 6 45 49                      30.L. |
|         | 01 00                       |   1 Repeated line                    |
|  66-  68| 00 04 29 03 00              | 1 5 46 49                      32.L. |
|  69-  71| 00 04 29 04                 | 1 5 46 50                      33.L. |
|         | 05 00                       |   5 Repeated lines                   |
|  72-  74| 00 05 28 04 00              | 1 6 46 50                      39.L. |
|  74-  77| 00 05 27 05                 | 1 6 45 50                      40.L. |
|         | 01 00                       |   1 Repeated line                    |
|  77-  79| 01 05 26 05 00              | 2 7 45 50                      42.L. |
|  80-  82| 01 05 25 06 00              | 2 7 44 50                      43.L. |
|  82-  84| 01 06 24 05 00              | 2 8 44 49                      44.L. |
|  85-  87| 01 07 22 06 00              | 2 9 43 49                      45.L. |
|  87-  89| 02 07 20 07 00              | 3 10 42 49                     46.L. |
|  90-  92| 02 08 1E 07 00              | 3 11 41 48                     47.L. |
|  92-  94| 02 0A 1A 09 00              | 3 13 39 48                     48.L. |
|  95-  97| 03 0B 16 0A 00              | 4 15 37 47                     49.L. |
|  97-  99| 03 0F 0F 0D 00              | 4 19 34 47                     50.L. |
| 100- 101| 04 29 00                    | 5 46                           51.L. |
| 101- 102| 05 28 00                    | 6 46                           52.L. |
| 103- 104| 06 26 00                    | 7 45                           53.L. |
| 104- 105| 07 24 00                    | 8 44                           54.L. |
| 106- 107| 08 22 00                    | 9 43                           55.L. |
| 107- 108| 09 20 00                    | 10 42                          56.L. |
| 109- 110| 0B 1C 00                    | 12 40                          57.L. |
| 110- 111| 0D 18 00                    | 14 38                          58.L. |
| 112- 113| 10 13 00                    | 17 36                          59.L. |
| 113- 114| 14 0C 00                    | 21 33                          60.L. |
|         |                             |                                      |
|---------|-----------------------------|--------------------------------------|
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|---------|------------------|-------------------------------------------------|
| WORDNO. |     CONTENT      |                    COMMENT                      |
|---------|------------------|-------------------------------------------------|
|    1    |                0 | Records      length of character                |
|    2    |              104 | Words                                           |
|---------|------------------|-------------------------------------------------|
|       NAME SECTION                                                           |
|       ------------                                                           |
|    3    |                3 | Length of name section                          |
|    4    |              303 | Character number                                |
|    5    |                0 | Number of following part                        |
|---------|------------------|-------------------------------------------------|
|       SETTING INFORMATION                                                    |
|       -------------------                                                    |
|    6    |               12 | Length of setting information                   |
|    7    |                1 | Character type = letter                         |
|    8    |              152 | Number of transitions                           |
|    9    |               50 | Total set width (T=L+W+R)                       |
|   10    |                5 | Left side bearing (L)                           |
|   11    |               42 | Width (W)                                       |
|   12    |                3 | Right side bearing (R)                          |
|   13    |                1 | X-minimum                                       |
|   14    |               42 | X-maximum                                       |
|   15    |                0 | Y-minimum                                       |
|   16    |               48 | Y-maximum                                       |
|   17    |                1 | Unit is 1 pixel                                 |
|---------|------------------|-------------------------------------------------|
|       LINE INDEX                                                             |
|       ----------                                                             |
|   18    |                0 | Records                                         |
|   19    |                2 | Words      No line index in this format         |
|         |                  |                                                 |
|---------|------------------|-------------------------------------------------|
|       IMAGE INFORMATION                                                      |
|       -----------------                                                      |
|   20    |                          0 | Records   length of image information   |
|   21    |                         85 | Words                                   |
|         |                            |                                         |
|         |                            | Run lengths:                            |
| 22-  23 | 13 0B 00                   | 20 31                              1.L. |
| 23-  24 | 0F 13 00                   | 16 35                              2.L. |
| 25-  26 | 0D 18 00                   | 14 38                              3.L. |
| 26-  27 | 0B 1C 00                   | 12 40                              4.L. |
| 28-  29 | 09 20 00                   | 10 42                              5.L. |
| 29-  30 | 08 22 00                   | 9 43                               6.L. |
| 31-  32 | 06 25 00                   | 7 44                               7.L. |
| 32-  34 | 05 27                      | 6 45                               8.L. |
|         | 01 00                      |    1 Repeated line                      |
| 34-  35 | 04 29 00                   | 5 46                              10.L. |
| 36-  38 | 03 10 0C 0F 00             | 4 20 32 47                        11.L. |
| 38-  40 | 03 0C 14 0B 00             | 4 16 36 47                        12.L. |
| 41-  43 | 02 0B 19 09 00             | 3 14 39 48                        13.L. |
| 43-  45 | 02 09 1D 07 00             | 3 12 41 48                        14.L. |
| 46-  48 | 01 09 1F 07 00             | 2 11 42 49                        15.L. |
| 48-  50 | 01 08 21 06 00             | 2 10 43 49                        16.L. |
| 51-  53 | 01 07 23 05 00             | 2 9 44 49                         17.L. |
| 53-  55 | 00 07 24 05 00             | 1 8 44 49                         18.L. |
| 56-  58 | 00 07 25 05 00             | 1 8 45 50                         19.L. |
| 58-  61 | 00 06 26 05                | 1 7 45 50                         20.L. |
|         | 01 00                      |    1 Repeated line                      |
| 61-  63 | 00 06 27 04 00             | 1 7 46 50                         22.L. |
|---------|----------------------------|-----------------------------------------|
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 |---------|-----------------------------|-----------------------------------------|
 | WORDNO. |           CONTENT           |                 COMMENT                 |
 |---------|-----------------------------|-----------------------------------------|
 |  64-  66| 00 05 28 04                 | 1 6 46 50                          23.L. |
 |         | 04 00                       |    4 Repeated lines                     |
 |  67-  69| 01 04 28 04                 | 2 6 46 50                          28.L. |
 |         | 01 00                       |    1 Repeated line                      |
 |  70-  72| 01 04 27 04 00              | 2 6 45 49                          30.L. |
 |  72-  75| 01 05 1C 03 07 04 00        | 2 7 35 38 45 49                    31.L. |
 |  76-  79| 02 04 1A 07 04 05 00        | 3 7 33 40 44 49                    32.L. |
 |  79-  82| 02 04 1A 08 02 06 00        | 3 7 33 41 43 49                    33.L. |
 |  83-  85| 03 03 19 10 00              | 4 7 32 48                          34.L. |
 |  85-  87| 03 04 18 10 00              | 4 8 32 48                          35.L. |
 |  88-  90| 04 03 18 0F 00              | 5 8 32 47                          36.L. |
 |  90-  92| 04 04 17 0F 00              | 5 9 32 47                          37.L. |
 |  93-  95| 05 04 16 0E 00              | 6 10 32 46                         38.L. |
 |  95-  97| 06 04 16 0C 00              | 7 11 33 45                         39.L. |
 |  98- 100| 07 03 16 0B 00              | 8 11 33 44                         40.L. |
 | 100- 102| 08 01 18 09 00              | 9 10 34 43                         41.L. |
 | 103- 104| 23 05 00                    | 36 41                              42.L. |
 |         |                             |                                         |
 |---------|-----------------------------|-----------------------------------------|
 |                                                                                 |
 |                              GRAND TOTAL                                        |
 |                              -----------                                        |
 |                                                WORDS          KBYTES            |
 |                                                -----          ------            |
 |   Length of font:                              14983          29.966            |
 |   Length of font header:                         484           0.968            |
 |   Length of all character headers:              2565           5.130            |
 |   Length of total image information:           11934          23.868            |
 |                                                                                 |
 |            DIGITIZATIONS                           NUMBER                       |
 |            -------------                           ------                       |
 |            Lines:                                    6429                       |
 |            Total of transitions:                    22481                       |
 |            ----------------------------------------------                       |
 |            Characters:                                135                       |
 |            Records (a 2048 words):                      8                       |
 |            ----------------------------------------------                       |
 |            Raster (grid):                       100 X 100                       |
 |            ----------------------------------------------                       |
 |            Digitizations per line:                   3.50                       |
 |            Lines per character:                        48                       |
 |            Image information per character:           177 bytes                 |
 |                                                                                 |
 |                                                                                 |
-----------------------------------------------------------------------------------
```

Appendix O
Description of the SN format

1. Structure of an SN font

The structure of an SN font is as described in appendix G together with the extended structure as in appendix K.

2. Description of the SN format

The **scanline nibble format** is a variation of the SC format especially suited for rasters between 30 × 30 up to 140 × 140. We propose to use this format instead of bitmaps in laser printers. It needs less storage capacity (see grand total of SC and SN format).
Basically, a byte is replaced by a halfbyte, the nibble. So, one has described a very short run length by a nibble. The nibbles 8...F indicate that the high value three bits are given with this nibble, and the low value three bits follow in the next nibble. One uses as many nibbles as are needed. Each further nibble gives three bits more. The later a nibble occurs in a sequence for one run length, the lower is its value.

Coding examples

Nibbles	Coded run length	Comment
0	0	Either black line start (non-white) or scanline end
00	0	Empty scanline
1	1	3 bit run length
7	7	3 bit run length
90	8	6 bit run length
F7	63	6 bit run length
980	64	9 bit run length
FF7	511	9 bit run length

Nibbles	Coded run length	Comment
9880	512	12 bit run length
FFF7	4095	12 bit run length
98880	4096	15 bit run length
.	.	.
.	.	.
.	.	.
etc.	etc.	etc.

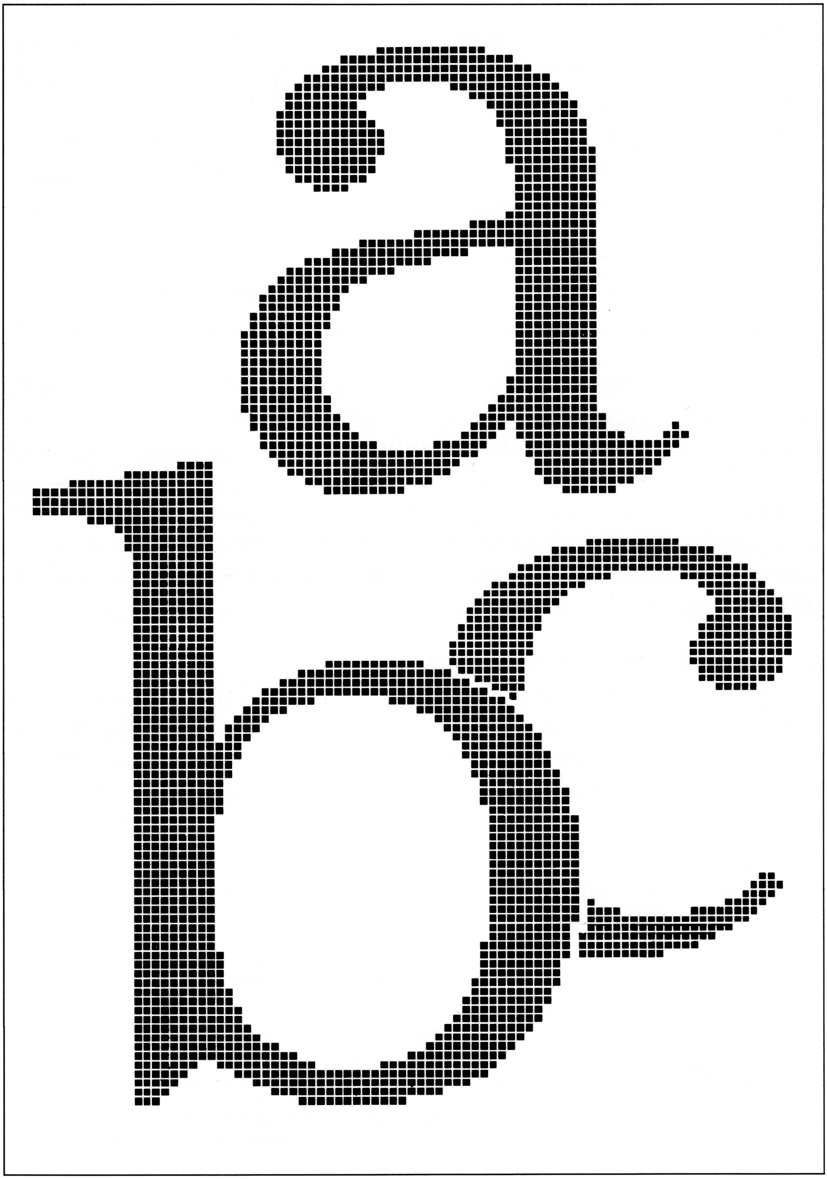
The number of line repetitions is written just behind the run lengths of a scanline, if applicable. As a scanline always has to have an even number of run lengths, this notation gives an odd number and can be easily recognized.

The end of the character is controlled using the line index and correspondingly, the end of a font is checked in the character index.

One run length, no matter whether coded with 3, 6, 9, 12 or 15 bits, is counted as one digitization.

3. Example of an SN format

First of all we represent the lower case letters a, b, c of the typeface “URW Antiqua 2015 normal”, as a raster image. The scanning identification is 21 (CRT machines). The raster is 100 × 100 for the em. Subsequently the type font format is reproduced as a data list.



```
AN201512.SN                    3-APR-87                    PAGE   1

|---------|-------------------|----------------------------------------------|
| WORDNO. |      CONTENT      |                     COMMENT                  |
|---------|-------------------|----------------------------------------------|
|    1    |                484| Length of font header                        |
|---------|-------------------|----------------------------------------------|
|      NAME SECTION                                                          |
|      ------------                                                          |
|    2    |                 55| Length of name section                       |
|    3    |                825| Number on URW list                           |
|  4 - 10 |  AN201512.SN      | File name (ASCII)                            |
|         |                   |                                              |
| 11 - 49 |        URW-Antiqua 2000             | Font name (ASCII)      |
|         |              normal                                              |
|         |                   |                                              |
|   50    |                 SN| Data format (ASCII)                          |
| 51 - 53 |          20  3 87 | Production date:      20-Mar-87              |
| 54 - 56 |           3  4 87 | Date of last change:  3-Apr-87               |
|---------|-------------------|----------------------------------------------|
|      FONT INFORMATION                                                      |
|      ----------------                                                      |
|   57    |                 19| Length of font information                   |
|   58    |                  1| Indicator for font                           |
|   59    |                135| Number of characters                         |
|   60    |                 67| Cap height (in pixels)                       |
|   61    |                100| Body size (in pixels)                        |
|   62    |                 47| x-height (in pixels)                         |
|   63    |                 25| Distance: base line - lower body line(in pixels)
|   64    |                100| Text line distance for setting (in pixels)   |
|   65    |                 10| Stem thickness (in pixels)                   |
|   66    |                  0| Angle of italisation (in 1/10 degree)        |
|   67    |                 12| Optimum point size for setting (in p)        |
|   68    |                 43| Average character width (in pixels)          |
|   69    |               1500| X-extension of a pixel (in 1/1000mm)         |
|   70    |               1500| Y-extension of a pixel (in 1/1000mm)         |
|   71    |                100| Em-resolution in X-direction (in pixels)     |
|   72    |                100| Em-resolution in Y-direction (in pixels)     |
|   73    |                 21| Scan indicator of image data                 |
|   74    |                  0| Width of printing window (in pixels)         |
|   75    |                  0| Height of printing window (in pixels)        |
|---------|-------------------|----------------------------------------------|
|      HIERARCHY SECTION                                                     |
|      -----------------                                                     |
|   76    |                  1| No hierarchy section in this format          |
|---------|-------------------|----------------------------------------------|
|       CHARACTER INDEX                                                      |
|      ----------------                                                      |
|   77    |                408| Length of character index                    |
|   78    |                  6| LENGTH OF FONT IN PHYSICAL RECORDS           |
|   79    |               1323| Last word of last record                     |
|         |                   |                                              |
|   80    |                101| Character number:  1                         |
|   81    |                  1| Pointer to record containing start of character
|   82    |                485| Word pointer to start of character           |
|         |                   |                                              |
|   83    |                102| Ch. no.: 2                                   |
|   84    |                  1| Record pointer                               |
|   85    |                606| Word pointer                                 |
|         |                   |                                              |
|  86- 88 |  103     1  692   | No., record pointer, word pointer of ch.:   3|
|  89- 91 |  104     1  798   | No., record pointer, word pointer of ch.:   4|
|  92- 94 |  105     1  876   | No., record pointer, word pointer of ch.:   5|
|---------|-------------------|----------------------------------------------|
   AN201512.SN                        3-APR-87                    PAGE   2

 |---------|------------------|------------------------------------------------|
 | WORDNO. |     CONTENT      |                    COMMENT                     |
 |---------|------------------|------------------------------------------------|
 |  95-  97|  106      1  957 | No., record pointer, word pointer of ch.:   6 |
 |  98- 100|  107      1 1029 | No., record pointer, word pointer of ch.:   7 |
 | 101- 103|  108      1 1147 | No., record pointer, word pointer of ch.:   8 |
 | 104- 106|  109      1 1213 | No., record pointer, word pointer of ch.:   9 |
 | 107- 109|  110      1 1252 | No., record pointer, word pointer of ch.:  10 |
 | 110- 112|  111      1 1314 | No., record pointer, word pointer of ch.:  11 |
 | 113- 115|  112      1 1437 | No., record pointer, word pointer of ch.:  12 |
 | 116- 118|  113      1 1489 | No., record pointer, word pointer of ch.:  13 |
 | 119- 121|  114      1 1609 | No., record pointer, word pointer of ch.:  14 |
 | 122- 124|  115      1 1719 | No., record pointer, word pointer of ch.:  15 |
 | 125- 127|  116      1 1834 | No., record pointer, word pointer of ch.:  16 |
 | 128- 130|  117      1 1911 | No., record pointer, word pointer of ch.:  17 |
 | 131- 133|  118      2   32 | No., record pointer, word pointer of ch.:  18 |
 | 134- 136|  119      2  133 | No., record pointer, word pointer of ch.:  19 |
 | 137- 139|  120      2  254 | No., record pointer, word pointer of ch.:  20 |
 | 140- 142|  121      2  319 | No., record pointer, word pointer of ch.:  21 |
 | 143- 145|  122      2  406 | No., record pointer, word pointer of ch.:  22 |
 | 146- 148|  123      2  520 | No., record pointer, word pointer of ch.:  23 |
 | 149- 151|  124      2  667 | No., record pointer, word pointer of ch.:  24 |
 | 152- 154|  125      2  811 | No., record pointer, word pointer of ch.:  25 |
 | 155- 157|  126      2  925 | No., record pointer, word pointer of ch.:  26 |
 | 158- 160|  127      2 1072 | No., record pointer, word pointer of ch.:  27 |
 | 161- 163|  128      2 1223 | No., record pointer, word pointer of ch.:  28 |
 | 164- 166|  129      2 1351 | No., record pointer, word pointer of ch.:  29 |
 | 167- 169|  201      2 1529 | No., record pointer, word pointer of ch.:  30 |
 | 170- 172|  208      2 1673 | No., record pointer, word pointer of ch.:  31 |
 | 173- 175|  210      2 1813 | No., record pointer, word pointer of ch.:  32 |
 | 176- 178|  237      2 1952 | No., record pointer, word pointer of ch.:  33 |
 | 179- 181|  251      3   43 | No., record pointer, word pointer of ch.:  34 |
 | 182- 184|  301      3  148 | No., record pointer, word pointer of ch.:  35 |
 | 185- 187|  302      3  245 | No., record pointer, word pointer of ch.:  36 |
 | 188- 190|  303      3  331 | No., record pointer, word pointer of ch.:  37 |
 | 191- 193|  304      3  409 | No., record pointer, word pointer of ch.:  38 |
 | 194- 196|  305      3  492 | No., record pointer, word pointer of ch.:  39 |
 | 197- 199|  306      3  587 | No., record pointer, word pointer of ch.:  40 |
 | 200- 202|  307      3  655 | No., record pointer, word pointer of ch.:  41 |
 | 203- 205|  308      3  789 | No., record pointer, word pointer of ch.:  42 |
 | 206- 208|  309      3  865 | No., record pointer, word pointer of ch.:  43 |
 | 209- 211|  310      3  910 | No., record pointer, word pointer of ch.:  44 |
 | 212- 214|  311      3  970 | No., record pointer, word pointer of ch.:  45 |
 | 215- 217|  312      3 1070 | No., record pointer, word pointer of ch.:  46 |
 | 218- 220|  313      3 1108 | No., record pointer, word pointer of ch.:  47 |
 | 221- 223|  314      3 1212 | No., record pointer, word pointer of ch.:  48 |
 | 224- 226|  315      3 1279 | No., record pointer, word pointer of ch.:  49 |
 | 227- 229|  316      3 1353 | No., record pointer, word pointer of ch.:  50 |
 | 230- 232|  317      3 1446 | No., record pointer, word pointer of ch.:  51 |
 | 233- 235|  318      3 1532 | No., record pointer, word pointer of ch.:  52 |
 | 236- 238|  319      3 1588 | No., record pointer, word pointer of ch.:  53 |
 | 239- 241|  320      3 1679 | No., record pointer, word pointer of ch.:  54 |
 | 242- 244|  321      3 1723 | No., record pointer, word pointer of ch.:  55 |
 | 245- 247|  322      3 1786 | No., record pointer, word pointer of ch.:  56 |
 | 248- 250|  323      3 1877 | No., record pointer, word pointer of ch.:  57 |
 | 251- 253|  324      3 2001 | No., record pointer, word pointer of ch.:  58 |
 | 254- 256|  325      4   66 | No., record pointer, word pointer of ch.:  59 |
 | 257- 259|  326      4  183 | No., record pointer, word pointer of ch.:  60 |
 | 260- 262|  327      4  293 | No., record pointer, word pointer of ch.:  61 |
 | 263- 265|  328      4  444 | No., record pointer, word pointer of ch.:  62 |
 | 266- 268|  329      4  583 | No., record pointer, word pointer of ch.:  63 |
 | 269- 271|  330      4  693 | No., record pointer, word pointer of ch.:  64 |
 |---------|------------------|------------------------------------------------|
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|---------|-----------------|----------------------------------------------|
| WORDNO. |     CONTENT     |                   COMMENT                    |
|---------|-----------------|----------------------------------------------|
| 272- 274|  331      4  805| No., record pointer, word pointer of ch.:  65
| 275- 277|  401      4  838| No., record pointer, word pointer of ch.:  66
| 278- 280|  408      4  959| No., record pointer, word pointer of ch.:  67
| 281- 283|  413      4 1086| No., record pointer, word pointer of ch.:  68
| 284- 286|  436      4 1185| No., record pointer, word pointer of ch.:  69
| 287- 289|  449      4 1294| No., record pointer, word pointer of ch.:  70
| 290- 292|  501      4 1386| No., record pointer, word pointer of ch.:  71
| 293- 295|  502      4 1431| No., record pointer, word pointer of ch.:  72
| 296- 298|  503      4 1548| No., record pointer, word pointer of ch.:  73
| 299- 301|  504      4 1664| No., record pointer, word pointer of ch.:  74
| 302- 304|  505      4 1736| No., record pointer, word pointer of ch.:  75
| 305- 307|  506      4 1840| No., record pointer, word pointer of ch.:  76
| 308- 310|  507      4 1941| No., record pointer, word pointer of ch.:  77
| 311- 313|  508      4 2034| No., record pointer, word pointer of ch.:  78
| 314- 316|  509      5   89| No., record pointer, word pointer of ch.:  79
| 317- 319|  510      5  188| No., record pointer, word pointer of ch.:  80
| 320- 322|  511      5  260| No., record pointer, word pointer of ch.:  81
| 323- 325|  512      5  399| No., record pointer, word pointer of ch.:  82
| 326- 328|  513      5  521| No., record pointer, word pointer of ch.:  83
| 329- 331|  601      5  607| No., record pointer, word pointer of ch.:  84
| 332- 334|  602      5  637| No., record pointer, word pointer of ch.:  85
| 335- 337|  603      5  675| No., record pointer, word pointer of ch.:  86
| 338- 340|  604      5  706| No., record pointer, word pointer of ch.:  87
| 341- 343|  605      5  737| No., record pointer, word pointer of ch.:  88
| 344- 346|  606      5  768| No., record pointer, word pointer of ch.:  89
| 347- 349|  607      5  817| No., record pointer, word pointer of ch.:  90
| 350- 352|  608      5  859| No., record pointer, word pointer of ch.:  91
| 353- 355|  609      5  916| No., record pointer, word pointer of ch.:  92
| 356- 358|  610      5  958| No., record pointer, word pointer of ch.:  93
| 359- 361|  611      5  999| No., record pointer, word pointer of ch.:  94
| 362- 364|  612      5 1062| No., record pointer, word pointer of ch.:  95
| 365- 367|  613      5 1123| No., record pointer, word pointer of ch.:  96
| 368- 370|  614      5 1186| No., record pointer, word pointer of ch.:  97
| 371- 373|  615      5 1235| No., record pointer, word pointer of ch.:  98
| 374- 376|  616      5 1284| No., record pointer, word pointer of ch.:  99
| 377- 379|  617      5 1367| No., record pointer, word pointer of ch.: 100
| 380- 382|  618      5 1446| No., record pointer, word pointer of ch.: 101
| 383- 385|  619      5 1515| No., record pointer, word pointer of ch.: 102
| 386- 388|  620      5 1584| No., record pointer, word pointer of ch.: 103

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|---------|-----------------|----------------------------------------------|
| WORDNO. |     CONTENT     |                   COMMENT                    |
|---------|-----------------|----------------------------------------------|
| 449- 451|  704      6  804| No., record pointer, word pointer of ch.: 124
| 452- 454|  705      6  847| No., record pointer, word pointer of ch.: 125
| 455- 457|  706      6  890| No., record pointer, word pointer of ch.: 126
| 458- 460|  709      6  941| No., record pointer, word pointer of ch.: 127
| 461- 463|  711      6  986| No., record pointer, word pointer of ch.: 128
| 464- 466|  751      6 1024| No., record pointer, word pointer of ch.: 129
| 467- 469|  753      6 1061| No., record pointer, word pointer of ch.: 130
| 470- 472|  754      6 1104| No., record pointer, word pointer of ch.: 131
| 473- 475|  755      6 1147| No., record pointer, word pointer of ch.: 132
| 476- 478|  756      6 1190| No., record pointer, word pointer of ch.: 133
| 479- 481|  759      6 1241| No., record pointer, word pointer of ch.: 134
| 482- 484|  761      6 1286| No., record pointer, word pointer of ch.: 135
|         |                 |                                              |
|---------|-----------------|----------------------------------------------|
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|---------|------------------|-----------------------------------------------------|
 WORDNO.  |     CONTENT      |                     COMMENT
----------|------------------|-----------------------------------------------------
    1     |                0 | Records       length of character
    2     |               97 | Words
----------|------------------|-----------------------------------------------------
      NAME SECTION
      ------------
    3     |                3 | Length of name section
    4     |              301 | Character number
    5     |                0 | Number of following part
----------|------------------|-----------------------------------------------------
      SETTING INFORMATION
      -------------------
    6     |               12 | Length of setting information
    7     |                1 | Character type = letter
    8     |              198 | Number of transitions
    9     |               51 | Total set width (T=L+W+R)
   10     |                4 | Left side bearing (L)
   11     |               49 | Width (W)
   12     |               -2 | Right side bearing (R)
   13     |                1 | X-minimum
   14     |               49 | X-maximum
   15     |                0 | Y-minimum
   16     |               48 | Y-maximum
   17     |                1 | Unit is 1 pixel
----------|------------------|-----------------------------------------------------
      LINE INDEX
      ----------
   18     |                0 | Records
   19     |                2 | Words      No line index in this format
          |                  |
----------|------------------|-----------------------------------------------------
      IMAGE INFORMATION
      -----------------
   20     |                            0 | Records   length of image information
   21     |                           78 | Words
          |                              |
          |                              | Run lengths:
  22-  23 | 91 91 0                      | 10 19                           1.L.
  23-  24 | 7  95 0                      | 8 21                            2.L.
  24-  25 | 5  A1 0                      | 6 23                            3.L.
  25-  26 | 4  A3 0                      | 5 24                            4.L.
  26-  27 | 3  A5 95 5  0                | 4 25 38 43                      5.L.
  28-  29 | 2  A7 92 91 0                | 3 26 36 45                      6.L.
  30-  31 | 2  A7 91 93 0                | 3 26 35 46                      7.L.
  32-  33 | 1  B1 90 94 0                | 2 27 35 47                      8.L.
  34-  35 | 1  B1 7  95 0                | 2 27 34 47                      9.L.
  35-  38 | 0  93 7  90 7  96 0          | 1 12 19 27 34 48               10.L.
  38-  40 | 0  91 93 7  6  96 0          | 1 10 21 28 34 48               11.L.
  40-  43 | 0  90 96 5  6  97 0          | 1 9 23 28 34 49                12.L.
  43-  45 | 0  7  A0 4  7  96 0          | 1 8 24 28 35 49                13.L.
  45-  48 | 0  6  A1 5  6  90 1  5  0    | 1 7 24 29 35 43 44 49          14.L.
  48-  50 | 0  6  A2 4  7  6  3  4  0    | 1 7 25 29 36 42 45 49          15.L.
  50-  53 | 0  5  A3 4  91 3  4  5  0    | 1 6 25 29 38 41 45 50          16.L.
  53-  55 | 0  5  A3 4  A1 4  0          | 1 6 25 29 46 50                17.L.
  55-  57 | 0  5  A4 3  A1 4  0          | 1 6 26 29 46 50                18.L.
  58-  60 | 1  4  A4 3  A1 4  0          | 2 6 26 29 46 50                19.L.
  60-  62 | 1  4  A4 4  A0 4            | 2 6 26 30 46 50                20.L.
          | 1  0                         |    1 Repeated line
  62-  65 | 2  4  A4 3  A0 4             | 3 7 27 30 46 50                22.L.
|---------|------------------------------|---------------------------------------|
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 |---------- |------------------------------ |----------------------------------------- |
 | WORDNO.   |            CONTENT            |                 COMMENT                  |
 |---------- |------------------------------ |----------------------------------------- |
 |           |1  0                           |   1 Repeated line                        |
 |   65-  67 |3  3   A4 3   97 5   0         | 4 7 27 30 45 50                  24.L.   |
 |   67-  69 |4  3   A3 3   97 5   0         | 5 8 27 30 45 50                  25.L.   |
 |   69-  71 |4  4   A3 3   95 6   0         | 5 9 28 31 44 50                  26.L.   |
 |   72-  74 |5  4   A2 3   95 6   0         | 6 10 28 31 44 50                 27.L.   |
 |   74-  76 |6  4   A1 3   94 6   0         | 7 11 28 31 43 49                 28.L.   |
 |   76-  78 |7  4   A0 3   92 90  0         | 8 12 28 31 41 49                 29.L.   |
 |   79-  81 |90 5   96 4   5  94  0         | 9 14 28 32 37 49                 30.L.   |
 |   81-  82 |6  D1  0                       | 7 48                             31.L.   |
 |   82-  83 |4  D3  0                       | 5 48                             32.L.   |
 |   83-  84 |2  D4  0                       | 3 47                             33.L.   |
 |   84-  85 |1  D5  0                       | 2 47                             34.L.   |
 |   85-  86 |1  D4  0                       | 2 46                             35.L.   |
 |   86-  87 |0  D4  0                       | 1 45                             36.L.   |
 |   87-  88 |0  D3  0                       | 1 44                             37.L.   |
 |   88-  89 |0  D1  0                       | 1 42                             38.L.   |
 |   89-  90 |0  C6  0                       | 1 39                             39.L.   |
 |   90-  91 |0  91  0                       | 1 10                             40.L.   |
 |   91-  92 |0  7   0                       | 1 8                              41.L.   |
 |   92-  92 |1  6   0                       | 2 8                              42.L.   |
 |   93-  93 |1  5   0                       | 2 7                              43.L.   |
 |   93-  94 |2  4                           | 3 7                              44.L.   |
 |           |1  0                           |   1 Repeated line                        |
 |   94-  95 |3  3   0                       | 4 7                              46.L.   |
 |   95-  96 |4  3   0                       | 5 8                              47.L.   |
 |   96-  96 |5  3   0                       | 6 9                              48.L.   |
 |   97-  97 |6  1   0                       | 7 8                              49.L.   |
 |           |                               |                                          |
 |---------- |------------------------------ |----------------------------------------- |
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 |---------|-------------------|--------------------------------------------------|
 | WORDNO. |      CONTENT      |                     COMMENT                      |
 |---------|-------------------|--------------------------------------------------|
 |    1    |                 0 | Records      length of character                 |
 |    2    |                86 | Words                                            |
 |---------|-------------------|--------------------------------------------------|
 |      NAME SECTION                                                              |
 |      ------------                                                              |
 |    3    |                 3 | Length of name section                           |
 |    4    |               302 | Character number                                 |
 |    5    |                 0 | Number of following part                         |
 |---------|-------------------|--------------------------------------------------|
 |      SETTING INFORMATION                                                       |
 |      -------------------                                                       |
 |    6    |                12 | Length of setting information                    |
 |    7    |                 1 | Character type = letter                          |
 |    8    |               180 | Number of transitions                            |
 |    9    |                65 | Total set width (T=L+W+R)                        |
 |   10    |                 0 | Left side bearing (L)                            |
 |   11    |                60 | Width (W)                                        |
 |   12    |                 5 | Right side bearing (R)                           |
 |   13    |                 1 | X-minimum                                        |
 |   14    |                60 | X-maximum                                        |
 |   15    |                 0 | Y-minimum                                        |
 |   16    |                70 | Y-maximum                                        |
 |   17    |                 1 | Unit is 1 pixel                                  |
 |---------|-------------------|--------------------------------------------------|
 |      LINE INDEX                                                                |
 |      ----------                                                                |
 |   18    |                 0 | Records                                          |
 |   19    |                 2 | Words      No line index in this format          |
 |         |                   |                                                  |
 |---------|-------------------|--------------------------------------------------|
 |      IMAGE INFORMATION                                                         |
 |      -----------------                                                         |
 |   20    |                             0 | Records   length of image information  |
 |   21    |                            67 | Words                                  |
 |         |                               |                                        |
 |         |                               | Run lengths:                           |
 |  22-  23| 98 3                          | 66 69                             1.L. |
 |         | 3  0                          |    3 Repeated lines                    |
 |  23-  24| 98 4                          | 66 70                             5.L. |
 |         | 1  0                          |    1 Repeated line                     |
 |  25-  26| 98 5                          | 65 70                             7.L. |
 |         | 2  0                          |    2 Repeated lines                    |
 |  26-  27| F7 6  0                       | 64 70                            10.L. |
 |  27-  28| F5 91 0                       | 62 71                            11.L. |
 |  28-  30| 0  98                         | 1 71                             12.L. |
 |         | 2  0                          |    2 Repeated lines                    |
 |  30-  31| 1  98 0                       | 2 71                             15.L. |
 |  31-  32| 2  98 0                       | 3 71                             16.L. |
 |  32-  33| 3  98 0                       | 4 72                             17.L. |
 |  34-  35| 4  98 0                       | 5 72                             18.L. |
 |  35-  36| 5  98                         | 6 72                             19.L. |
 |         | 1  0                          |    1 Repeated line                     |
 |  36-  38| 4  95 97 90 0                 | 5 18 33 41                       21.L. |
 |  38-  40| 4  91 A7 6  0                 | 5 14 37 43                       22.L. |
 |  40-  42| 3  90 B3 5  0                 | 4 12 39 44                       23.L. |
 |  42-  43| 3  6  B7 4  0                 | 4 10 41 45                       24.L. |
 |  43-  45| 2  6  C1 4  0                 | 3 9 42 46                        25.L. |
 |  45-  46| 2  5  C3 4  0                 | 3 8 43 47                        26.L. |
 |---------|-------------------------------|----------------------------------------|
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 |---------|------------------------------|---------------------------------------|
 | WORDNO. |          CONTENT             |                COMMENT                |
 |---------|------------------------------|---------------------------------------|
 |  46-  48| 1  6  C4 3  0                | 2 8 44 47                      27.L.  |
 |  48-  49| 1  5  C5 4  0                | 2 7 44 48                      28.L.  |
 |  49-  51| 1  5  C6 3  0                | 2 7 45 48                      29.L.  |
 |  51-  52| 0  5  C7 4                   | 1 6 45 49                      30.L.  |
 |         | 1  0                         |    1 Repeated line                    |
 |  53-  54| 0  4  D1 3  0                | 1 5 46 49                      32.L.  |
 |  54-  56| 0  4  D1 4                   | 1 5 46 50                      33.L.  |
 |         | 5  0                         |    5 Repeated lines                   |
 |  56-  57| 0  5  D0 4  0                | 1 6 46 50                      39.L.  |
 |  57-  59| 0  5  C7 5                   | 1 6 45 50                      40.L.  |
 |         | 1  0                         |    1 Repeated line                    |
 |  59-  60| 1  5  C6 5  0                | 2 7 45 50                      42.L.  |
 |  61-  62| 1  5  C5 6  0                | 2 7 44 50                      43.L.  |
 |  62-  63| 1  6  C4 5  0                | 2 8 44 49                      44.L.  |
 |  64-  65| 1  7  C2 6  0                | 2 9 43 49                      45.L.  |
 |  65-  66| 2  7  C0 7  0                | 3 10 42 49                     46.L.  |
 |  67-  68| 2  90 B6 7  0                | 3 11 41 48                     47.L.  |
 |  68-  70| 2  92 B2 91 0                | 3 13 39 48                     48.L.  |
 |  70-  72| 3  93 A6 92 0                | 4 15 37 47                     49.L.  |
 |  72-  74| 3  97 97 95 0                | 4 19 34 47                     50.L.  |
 |  74-  75| 4  D1 0                      | 5 46                           51.L.  |
 |  75-  76| 5  D0 0                      | 6 46                           52.L.  |
 |  76-  77| 6  C6 0                      | 7 45                           53.L.  |
 |  77-  78| 7  C4 0                      | 8 44                           54.L.  |
 |  78-  79| 90 C2 0                      | 9 43                           55.L.  |
 |  80-  81| 91 C0 0                      | 10 42                          56.L.  |
 |  81-  82| 93 B4 0                      | 12 40                          57.L.  |
 |  82-  83| 95 B0 0                      | 14 38                          58.L.  |
 |  83-  84| A0 A3 0                      | 17 36                          59.L.  |
 |  85-  86| A4 94 0                      | 21 33                          60.L.  |
 |         |                              |                                       |
 |---------|------------------------------|---------------------------------------|
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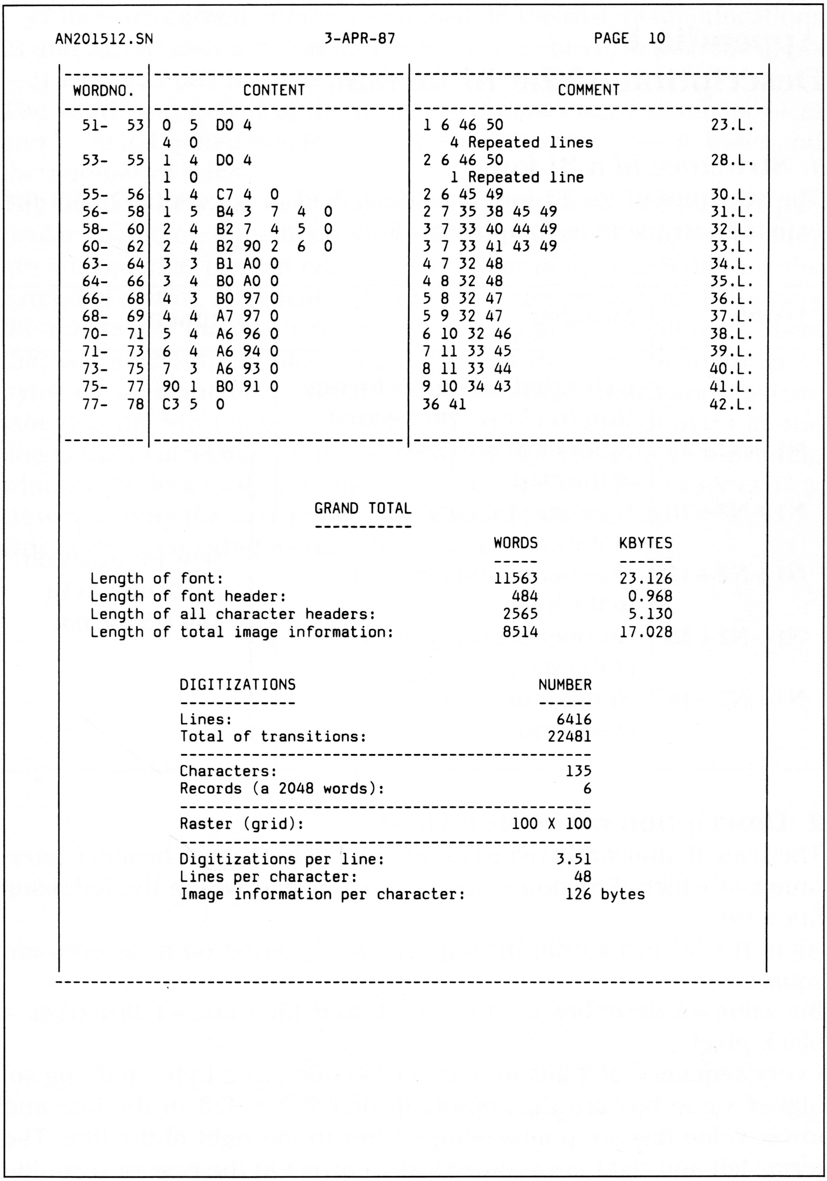
|---------|------------------|----------------------------------------------------|
| WORDNO. |     CONTENT      |                      COMMENT                       |
|---------|------------------|----------------------------------------------------|
|     1   |                 0| Records     length of character                    |
|     2   |                78| Words                                              |
|---------|------------------|----------------------------------------------------|
|      NAME SECTION                                                               |
|      ------------                                                               |
|     3   |                 3| Length of name section                             |
|     4   |               303| Character number                                   |
|     5   |                 0| Number of following part                           |
|---------|------------------|----------------------------------------------------|
|      SETTING INFORMATION                                                        |
|      -------------------                                                        |
|     6   |                12| Length of setting information                      |
|     7   |                 1| Character type = letter                            |
|     8   |               152| Number of transitions                              |
|     9   |                50| Total set width (T=L+W+R)                          |
|    10   |                 5| Left side bearing (L)                              |
|    11   |                42| Width (W)                                          |
|    12   |                 3| Right side bearing (R)                             |
|    13   |                 1| X-minimum                                          |
|    14   |                42| X-maximum                                          |
|    15   |                 0| Y-minimum                                          |
|    16   |                48| Y-maximum                                          |
|    17   |                 1| Unit is 1 pixel                                    |
|---------|------------------|----------------------------------------------------|
|      LINE INDEX                                                                 |
|      ----------                                                                 |
|    18   |                 0| Records                                            |
|    19   |                 2| Words      No line index in this format            |
|         |                  |                                                    |
|---------|------------------|----------------------------------------------------|
|      IMAGE INFORMATION                                                          |
|      -----------------                                                          |
|    20   |                            0| Records   length of image information    |
|    21   |                           59| Words                                    |
|         |                             |                                          |
|         |                             | Run lengths:                             |
|  22-  23| A3 93 0                     | 20 31                              1.L.  |
|  23-  24| 97 A3 0                     | 16 35                              2.L.  |
|  24-  25| 95 B0 0                     | 14 38                              3.L.  |
|  25-  26| 93 B4 0                     | 12 40                              4.L.  |
|  27-  28| 91 C0 0                     | 10 42                              5.L.  |
|  28-  29| 90 C2 0                     | 9 43                               6.L.  |
|  29-  30| 6  C5 0                     | 7 44                               7.L.  |
|  30-  31| 5  C7                       | 6 45                               8.L.  |
|         | 1  0                        |    1 Repeated line                       |
|  31-  32| 4  D1 0                     | 5 46                              10.L.  |
|  32-  34| 3  A0 94 97 0               | 4 20 32 47                        11.L.  |
|  34-  36| 3  94 A4 93 0               | 4 16 36 47                        12.L.  |
|  36-  38| 2  93 B1 91 0               | 3 14 39 48                        13.L.  |
|  38-  40| 2  91 B5 7  0               | 3 12 41 48                        14.L.  |
|  40-  42| 1  91 B7 7  0               | 2 11 42 49                        15.L.  |
|  42-  43| 1  90 C1 6  0               | 2 10 43 49                        16.L.  |
|  44-  45| 1  7  C3 5  0               | 2 9 44 49                         17.L.  |
|  45-  46| 0  7  C4 5  0               | 1 8 44 49                         18.L.  |
|  47-  48| 0  7  C5 5  0               | 1 8 45 50                         19.L.  |
|  48-  50| 0  6  C6 5                  | 1 7 45 50                         20.L.  |
|         | 1  0                        |    1 Repeated line                       |
|  50-  51| 0  6  C7 4  0               | 1 7 46 50                         22.L.  |
|---------|-----------------------------|------------------------------------------|
```



```
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 |---------|----------------------------|----------------------------------------|
 | WORDNO. |          CONTENT           |                COMMENT                 |
 |---------|----------------------------|----------------------------------------|
 |  51-  53| 0  5  D0 4                 | 1 6 46 50                        23.L.  |
 |         | 4  0                       |    4 Repeated lines                    |
 |  53-  55| 1  4  D0 4                 | 2 6 46 50                        28.L.  |
 |         | 1  0                       |    1 Repeated line                     |
 |  55-  56| 1  4  C7 4  0              | 2 6 45 49                        30.L.  |
 |  56-  58| 1  5  B4 3  7  4  0        | 2 7 35 38 45 49                  31.L.  |
 |  58-  60| 2  4  B2 7  4  5  0        | 3 7 33 40 44 49                  32.L.  |
 |  60-  62| 2  4  B2 90 2  6  0        | 3 7 33 41 43 49                  33.L.  |
 |  63-  64| 3  3  B1 A0 0              | 4 7 32 48                        34.L.  |
 |  64-  66| 3  4  B0 A0 0              | 4 8 32 48                        35.L.  |
 |  66-  68| 4  3  B0 97 0              | 5 8 32 47                        36.L.  |
 |  68-  69| 4  4  A7 97 0              | 5 9 32 47                        37.L.  |
 |  70-  71| 5  4  A6 96 0              | 6 10 32 46                       38.L.  |
 |  71-  73| 6  4  A6 94 0              | 7 11 33 45                       39.L.  |
 |  73-  75| 7  3  A6 93 0              | 8 11 33 44                       40.L.  |
 |  75-  77| 90 1  B0 91 0              | 9 10 34 43                       41.L.  |
 |  77-  78| C3 5  0                    | 36 41                            42.L.  |
 |         |                            |                                        |
 |---------|----------------------------|----------------------------------------|
 |                                                                               |
 |                               GRAND TOTAL                                     |
 |                               -----------                                     |
 |                                              WORDS          KBYTES            |
 |                                              -----          ------            |
 |    Length of font:                           11563          23.126            |
 |    Length of font header:                      484           0.968            |
 |    Length of all character headers:           2565           5.130            |
 |    Length of total image information:         8514          17.028            |
 |                                                                               |
 |              DIGITIZATIONS                            NUMBER                  |
 |              -------------                            ------                  |
 |              Lines:                                     6416                  |
 |              Total of transitions:                     22481                  |
 |              ----------------------------------------------                  |
 |              Characters:                                 135                  |
 |              Records (a 2048 words):                       6                  |
 |              ----------------------------------------------                  |
 |              Raster (grid):                        100 X 100                  |
 |              ----------------------------------------------                  |
 |              Digitizations per line:                    3.51                  |
 |              Lines per character:                         48                  |
 |              Image information per character:          126 bytes            |
 |                                                                               |
 |                                                                               |
---------------------------------------------------------------------------------
```

Appendix P
Description of the BI format

1. Structure of a BI font

The structure of the BI font is as described in appendix G with the extended structure as in appendix K.

Word	Meaning	Comment
	Extended setting information in character record	
N1 + N2 + 15	Number of zero bytes at the start	New information, particular to BI and GS format
N1 + N2 + 16	Number of zero bytes at the end	
N1 + N2 + 17	Number of non zero bytes in the lines	
N1 + N2 + 18	Number of empty lines at the start	
N1 + N2 + 19	Number of empty lines at the end	

2. Description of the BI format

The scan identification (word number I + 18 in the font header) determines in which direction a line progresses and where the following lines are.

As in the SC format the **bitmap format** is based on a rastered em square.

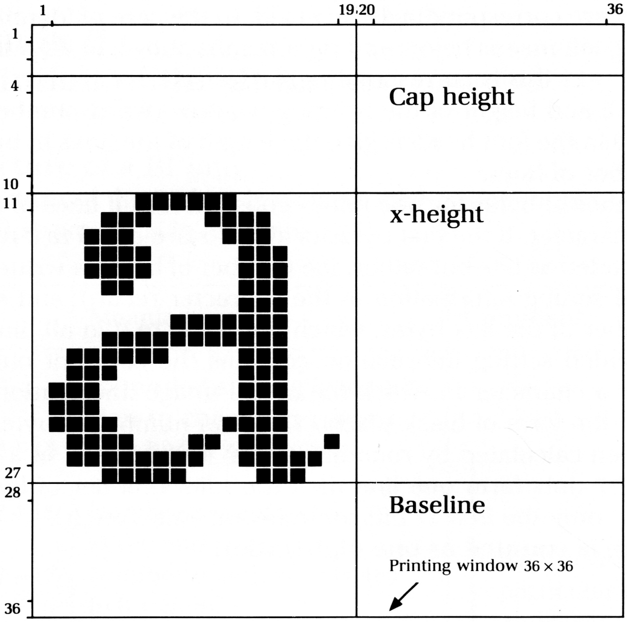
Bit value = 0 describes a white pixel, and bit value = 1 describes a black pixel.

Every sequence of 8 bits in one line is coded as a byte. In doing so, higher value bits are thus points further to the left in the line and lower value bits are points lying further to the right of the line. The terms left and right are geometrically correct in the case of scanning identifications 11 and 12, and in the case of identifications −11 and −12 they are correspondingly reversed. In the case of identifications 21 and 22, left means below and right means above, in identifications −21 and −22 this is correspondingly reversed.

The width and height of the printing window (word numbers I+19 and I+20 in the font header) give the length of the lines in bytes and the number of lines.

The number of bytes for one line is constant for all lines of any particular character. If the first bytes of all lines are equal to 0 then they are not coded as bits but rather, the number of bytes is written in the extended setting information in the character record, and similarly the number of the last bytes, which are equal to 0 in all lines. Also, the extended setting information contains the constant number of bytes for a character in which the actual image information is contained in the form of black pixels. The total number of bytes in one line is then calculated by rounding up. If, for example, in a printing window 17 dots form one line then the total number of bytes is 3. However, only the first 17 bits are relevant (see sketch).

One byte is counted as one digitization.


1
19
20
36
1
4
10
11
27
28
36
Cap height
x-height
Baseline
Printing window 36 × 36

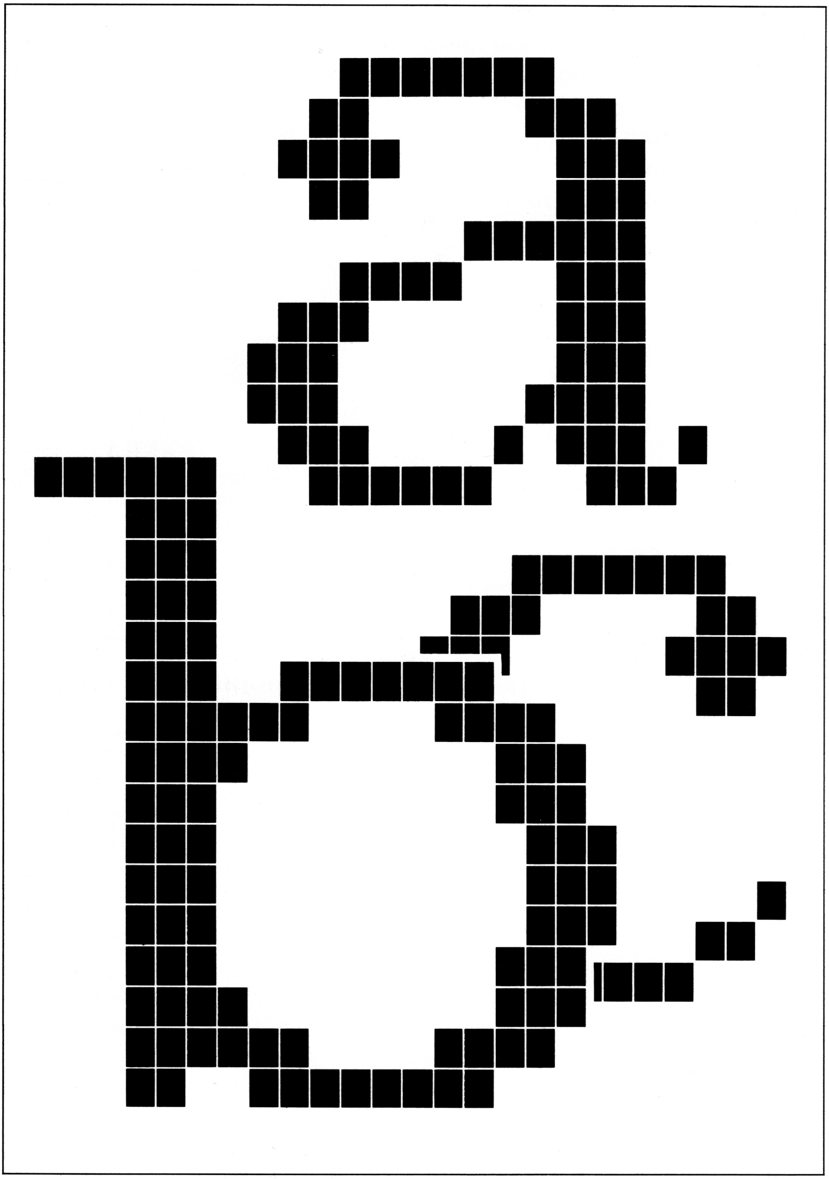
Example for additional setting information

Scanning code −21 (⇊) results in:
Number of zero bytes at start: 1
Number of zero bytes at end: 1
Number of non zero bytes: 3
Number of empty lines at start: 1
Number of empty lines at end: 18

Scanning code 12 (⇉) results in:
Number of zero bytes at start: 0
Number of zero bytes at end: 2
Number of non zero bytes: 3
Number of empty lines at start: 10
Number of empty lines at end: 9

3. Example of a BI format

First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", as a raster image. The scanning identification is 12 (laser printer). The raster is 32 × 24 for the em. The printing window correspondingly has a height of 24 and a length of 32. This relationship is not imperative, however. Subsequently, the type font format is reproduced as a data list.



```
AN201512.BI                   3-FEB-87                    PAGE   1

|---------|------------------|-------------------------------------------------|
 WORDNO.  |     CONTENT      |                     COMMENT
 ---------|------------------|-------------------------------------------------
     1    |               484| Length of font header
 ---------|------------------|-------------------------------------------------
      NAME SECTION
      ------------
     2    |                55| Length of name section
     3    |               825| Number on URW list
  4 - 10  |   AN201512.BI    | File name (ASCII)
          |                  |
 11 - 49  |        URW-Antiqua 2000                   | Font name (ASCII)
          |              normal
          |                  |
    50    |                BI| Data format (ASCII)
 51 - 53  |         29  1 87 | Production date:      29-Jan-87
 54 - 56  |         29  1 87 | Date of last change: 29-Jan-87
 ---------|------------------|-------------------------------------------------
      FONT INFORMATION
      ----------------
    57    |                19| Length of font information
    58    |                 1| Indicator for font
    59    |               135| Number of characters
    60    |                16| Cap height (in pixels)
    61    |                24| Body size (in pixels)
    62    |                12| x-height (in pixels)
    63    |                 6| Distance: base line - lower body line(in pixels)
    64    |                24| Text line distance for setting (in pixels)
    65    |                 3| Stem thickness (in pixels)
    66    |                 0| Angle of italisation (in 1/10 degree)
    67    |                12| Optimum point size for setting (in p)
    68    |                13| Average character width (in pixels)
    69    |              4688| X-extension of a pixel (in 1/1000mm)
    70    |              6250| Y-extension of a pixel (in 1/1000mm)
    71    |                32| Em-resolution in X-direction (in pixels)
    72    |                24| Em-resolution in Y-direction (in pixels)
    73    |                12| Scan indicator of image data
    74    |                32| Width of printing window (in pixels)
    75    |                24| Height of printing window (in pixels)
 ---------|------------------|-------------------------------------------------
      HIERARCHY SECTION
      -----------------
    76    |                 1| No hierarchy section in this format
 ---------|------------------|-------------------------------------------------
       CHARACTER INDEX
      ----------------
    77    |               408| Length of character index
    78    |                 4| LENGTH OF FONT IN PHYSICAL RECORDS
    79    |               173| Last word of last record

    80                    101  Character number:  1
    81                      1  Pointer to record containing start of character
    82                    485  Word pointer to start of character

    83                    102  Ch. no.: 2
    84                      1  Record pointer
    85                    537  Word pointer

  86-  88 |  103      1  589| No., record pointer, word pointer of ch.:     3
  89-  91 |  104      1  642| No., record pointer, word pointer of ch.:     4
  92-  94 |  105      1  694| No., record pointer, word pointer of ch.:     5
|---------|------------------|-------------------------------------------------|
AN201512.BI                          3-FEB-87                        PAGE   2

 ---------  ------------------  ------------------------------------------------
 WORDNO.         CONTENT                            COMMENT
 ---------  ------------------  ------------------------------------------------
   95-  97    106       1  746    No., record pointer, word pointer of ch.:     6
   98- 100    107       1  798    No., record pointer, word pointer of ch.:     7
  101- 103    108       1  851    No., record pointer, word pointer of ch.:     8
  104- 106    109       1  903    No., record pointer, word pointer of ch.:     9
  107- 109    110       1  946    No., record pointer, word pointer of ch.:    10
  110- 112    111       1  993    No., record pointer, word pointer of ch.:    11
  113- 115    112       1 1045    No., record pointer, word pointer of ch.:    12
  116- 118    113       1 1097    No., record pointer, word pointer of ch.:    13
  119- 121    114       1 1157    No., record pointer, word pointer of ch.:    14
  122- 124    115       1 1209    No., record pointer, word pointer of ch.:    15
  125- 127    116       1 1262    No., record pointer, word pointer of ch.:    16
  128- 130    117       1 1314    No., record pointer, word pointer of ch.:    17
  131- 133    118       1 1386    No., record pointer, word pointer of ch.:    18
  134- 136    119       1 1438    No., record pointer, word pointer of ch.:    19
  137- 139    120       1 1482    No., record pointer, word pointer of ch.:    20
  140- 142    121       1 1534    No., record pointer, word pointer of ch.:    21
  143- 145    122       1 1586    No., record pointer, word pointer of ch.:    22
  146- 148    123       1 1638    No., record pointer, word pointer of ch.:    23
  149- 151    124       1 1707    No., record pointer, word pointer of ch.:    24
  152- 154    125       1 1759    No., record pointer, word pointer of ch.:    25
  155- 157    126       1 1811    No., record pointer, word pointer of ch.:    26
  158- 160    127       1 1863    No., record pointer, word pointer of ch.:    27
  161- 163    128       1 1923    No., record pointer, word pointer of ch.:    28
  164- 166    129       1 1983    No., record pointer, word pointer of ch.:    29
  167- 169    201       1 2042    No., record pointer, word pointer of ch.:    30
  170- 172    208       2   52    No., record pointer, word pointer of ch.:    31
  173- 175    210       2  111    No., record pointer, word pointer of ch.:    32
  176- 178    237       2  170    No., record pointer, word pointer of ch.:    33
  179- 181    251       2  228    No., record pointer, word pointer of ch.:    34
  182- 184    301       2  286    No., record pointer, word pointer of ch.:    35
  185- 187    302       2  323    No., record pointer, word pointer of ch.:    36
  188- 190    303       2  373    No., record pointer, word pointer of ch.:    37
  191- 193    304       2  410    No., record pointer, word pointer of ch.:    38
  194- 196    305       2  463    No., record pointer, word pointer of ch.:    39
  197- 199    306       2  502    No., record pointer, word pointer of ch.:    40
  200- 202    307       2  546    No., record pointer, word pointer of ch.:    41
  203- 205    308       2  589    No., record pointer, word pointer of ch.:    42
  206- 208    309       2  642    No., record pointer, word pointer of ch.:    43
  209- 211    310       2  685    No., record pointer, word pointer of ch.:    44

AN201512.BI                          3-FEB-87                        PAGE   4

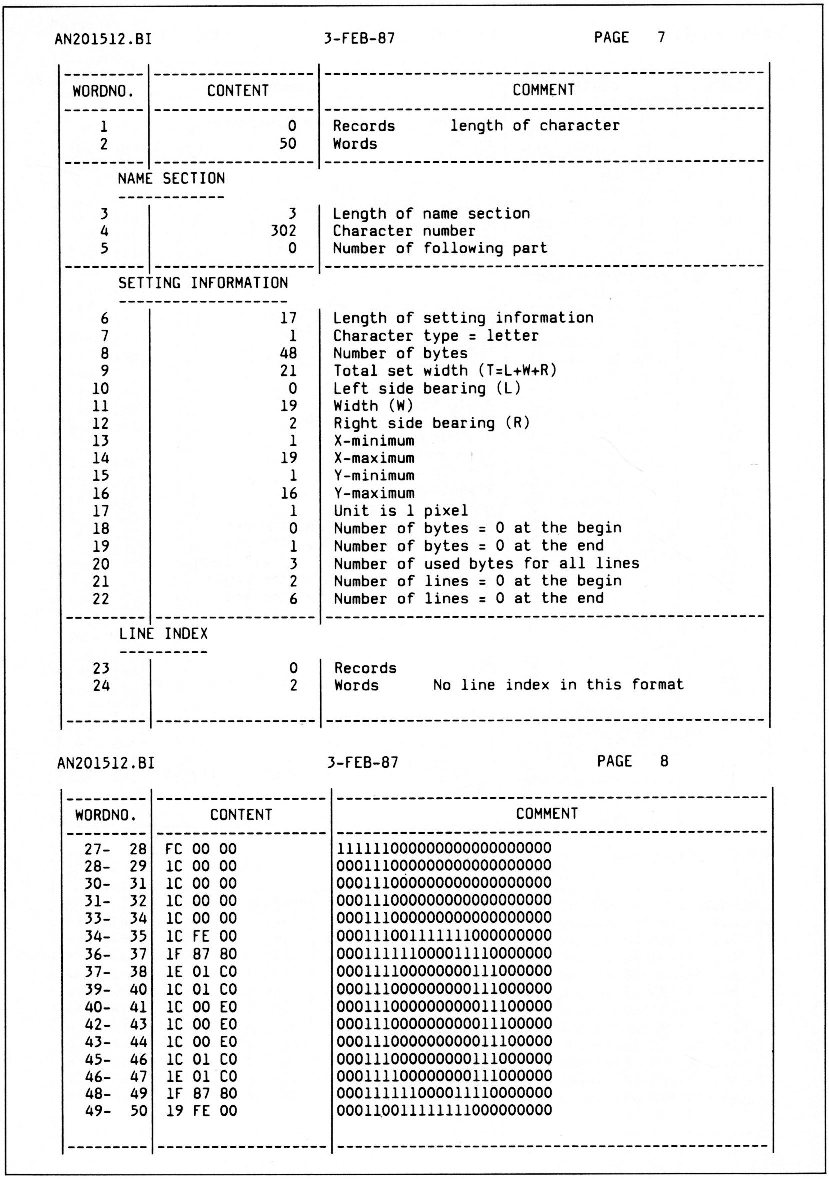
 ---------  ------------------  ------------------------------------------------
 WORDNO.         CONTENT                            COMMENT
 ---------  ------------------  ------------------------------------------------
  449- 451    704       3 1865    No., record pointer, word pointer of ch.:   124
  452- 454    705       3 1894    No., record pointer, word pointer of ch.:   125
  455- 457    706       3 1923    No., record pointer, word pointer of ch.:   126
  458- 460    709       3 1955    No., record pointer, word pointer of ch.:   127
  461- 463    711       3 1985    No., record pointer, word pointer of ch.:   128
  464- 466    751       3 2014    No., record pointer, word pointer of ch.:   129
  467- 469    753       3 2044    No., record pointer, word pointer of ch.:   130
  470- 472    754       4   25    No., record pointer, word pointer of ch.:   131
  473- 475    755       4   54    No., record pointer, word pointer of ch.:   132
  476- 478    756       4   83    No., record pointer, word pointer of ch.:   133
  479- 481    759       4  115    No., record pointer, word pointer of ch.:   134
  482- 484    761       4  145    No., record pointer, word pointer of ch.:   135

 ---------  ------------------  ------------------------------------------------
```

```
   AN201512.BI                         3-FEB-87                        PAGE    5

  |---------|-------------------|-------------------------------------------------|
  | WORDNO. |      CONTENT      |                     COMMENT                     |
  |---------|-------------------|-------------------------------------------------|
  |    1    |                 0 | Records      length of character                |
  |    2    |                37 | Words                                           |
  |---------|-------------------|-------------------------------------------------|
  |     NAME SECTION                                                              |
  |     ------------                                                              |
  |    3    |                 3 | Length of name section                          |
  |    4    |               301 | Character number                                |
  |    5    |                 0 | Number of following part                        |
  |---------|-------------------|-------------------------------------------------|
  |     SETTING INFORMATION                                                       |
  |     -------------------                                                       |
  |    6    |                17 | Length of setting information                   |
  |    7    |                 1 | Character type = letter                         |
  |    8    |                22 | Number of bytes                                 |
  |    9    |                16 | Total set width (T=L+W+R)                       |
  |   10    |                 1 | Left side bearing (L)                           |
  |   11    |                15 | Width (W)                                       |
  |   12    |                 0 | Right side bearing (R)                          |
  |   13    |                 1 | X-minimum                                       |
  |   14    |                15 | X-maximum                                       |
  |   15    |                 1 | Y-minimum                                       |
  |   16    |                11 | Y-maximum                                       |
  |   17    |                 1 | Unit is 1 pixel                                 |
  |   18    |                 0 | Number of bytes = 0 at the begin                |
  |   19    |                 2 | Number of bytes = 0 at the end                  |
  |   20    |                 2 | Number of used bytes for all lines              |
  |   21    |                 7 | Number of lines = 0 at the begin                |
  |   22    |                 6 | Number of lines = 0 at the end                  |
  |---------|-------------------|-------------------------------------------------|
  |     LINE INDEX                                                                |
  |     ----------                                                                |
  |   23    |                 0 | Records                                         |
  |   24    |                 2 | Words       No line index in this format        |
  |         |                   |                                                 |
  |---------|-------------------|-------------------------------------------------|
  |     IMAGE INFORMATION                                                         |
  |     -----------------                                                         |
  |   25    |                 0 |  Records   length of image information          |
  |   26    |                13 |  Words                                          |
  |         |                   |                                                 |
  |---------|-------------------|-------------------------------------------------|
   AN201512.BI                         3-FEB-87                        PAGE    6

  |---------|-------------------|-------------------------------------------------|
  | WORDNO. |      CONTENT      |                     COMMENT                     |
  |---------|-------------------|-------------------------------------------------|
  |  27-  27| 1F C0             |0001111111000000                                 |
  |  28-  28| 30 70             |0011000001110000                                 |
  |  29-  29| 78 38             |0111100000111000                                 |
  |  30-  30| 30 38             |0011000000111000                                 |
  |  31-  31| 01 F8             |0000000111111000                                 |
  |  32-  32| 1E 38             |0001111000111000                                 |
  |  33-  33| 70 38             |0111000000111000                                 |
  |  34-  34| E0 38             |1110000000111000                                 |
  |  35-  35| E0 78             |1110000001111000                                 |
  |  36-  36| 70 BA             |0111000010111010                                 |
  |  37-  37| 3F 1C             |0011111100011100                                 |
  |         |                   |                                                 |
  |---------|-------------------|-------------------------------------------------|
```



```
AN201512.BI                    3-FEB-87                    PAGE    7

|---------|------------------|----------------------------------------------|
| WORDNO. |     CONTENT      |                   COMMENT                    |
|---------|------------------|----------------------------------------------|
|    1    |                 0| Records      length of character             |
|    2    |                50| Words                                        |
|---------|------------------|----------------------------------------------|
|     NAME SECTION                                                          |
|     ------------                                                          |
|    3    |                 3| Length of name section                       |
|    4    |               302| Character number                             |
|    5    |                 0| Number of following part                     |
|---------|------------------|----------------------------------------------|
|     SETTING INFORMATION                                                   |
|     -------------------                                                   |
|    6    |                17| Length of setting information                |
|    7    |                 1| Character type = letter                      |
|    8    |                48| Number of bytes                              |
|    9    |                21| Total set width (T=L+W+R)                    |
|   10    |                 0| Left side bearing (L)                        |
|   11    |                19| Width (W)                                    |
|   12    |                 2| Right side bearing (R)                       |
|   13    |                 1| X-minimum                                    |
|   14    |                19| X-maximum                                    |
|   15    |                 1| Y-minimum                                    |
|   16    |                16| Y-maximum                                    |
|   17    |                 1| Unit is 1 pixel                              |
|   18    |                 0| Number of bytes = 0 at the begin             |
|   19    |                 1| Number of bytes = 0 at the end               |
|   20    |                 3| Number of used bytes for all lines           |
|   21    |                 2| Number of lines = 0 at the begin             |
|   22    |                 6| Number of lines = 0 at the end               |
|---------|------------------|----------------------------------------------|
|     LINE INDEX                                                            |
|     ----------                                                            |
|   23    |                 0| Records                                      |
|   24    |                 2| Words      No line index in this format      |
|         |                  |                                              |
|---------|------------------|----------------------------------------------|
```

```
AN201512.BI                    3-FEB-87                    PAGE    8

|---------|--------------------|----------------------------------------------|
| WORDNO. |      CONTENT       |                   COMMENT                    |
|---------|--------------------|----------------------------------------------|
|  27-  28| FC 00 00           |111111000000000000000000                      |
|  28-  29| 1C 00 00           |000111000000000000000000                      |
|  30-  31| 1C 00 00           |000111000000000000000000                      |
|  31-  32| 1C 00 00           |000111000000000000000000                      |
|  33-  34| 1C 00 00           |000111000000000000000000                      |
|  34-  35| 1C FE 00           |000111001111111000000000                      |
|  36-  37| 1F 87 80           |000111111000011110000000                      |
|  37-  38| 1E 01 C0           |000111100000000111000000                      |
|  39-  40| 1C 01 C0           |000111000000000111000000                      |
|  40-  41| 1C 00 E0           |000111000000000011100000                      |
|  42-  43| 1C 00 E0           |000111000000000011100000                      |
|  43-  44| 1C 00 E0           |000111000000000011100000                      |
|  45-  46| 1C 01 C0           |000111000000000111000000                      |
|  46-  47| 1E 01 C0           |000111100000000111000000                      |
|  48-  49| 1F 87 80           |000111111000011110000000                      |
|  49-  50| 19 FE 00           |000110011111111000000000                      |
|         |                    |                                              |
|---------|--------------------|----------------------------------------------|
AN201512.BI                    3-FEB-87                 PAGE   9

|---------|-------------------|---------------------------------------------------|
 WORDNO.  |      CONTENT      |                     COMMENT
|---------|-------------------|---------------------------------------------------|
     1    |                 0 | Records      length of character
     2    |                37 | Words
|---------|-------------------|---------------------------------------------------|
      NAME SECTION
      ------------
     3    |                 3 | Length of name section
     4    |               303 | Character number
     5    |                 0 | Number of following part
|---------|-------------------|---------------------------------------------------|
      SETTING INFORMATION
      -------------------
     6    |                17 | Length of setting information
     7    |                 1 | Character type = letter
     8    |                22 | Number of bytes
     9    |                16 | Total set width (T=L+W+R)
    10    |                 2 | Left side bearing (L)
    11    |                13 | Width (W)
    12    |                 1 | Right side bearing (R)
    13    |                 1 | X-minimum
    14    |                13 | X-maximum
    15    |                 1 | Y-minimum
    16    |                11 | Y-maximum
    17    |                 1 | Unit is 1 pixel
    18    |                 0 | Number of bytes = 0 at the begin
    19    |                 2 | Number of bytes = 0 at the end
    20    |                 2 | Number of used bytes for all lines
    21    |                 7 | Number of lines = 0 at the begin
    22    |                 6 | Number of lines = 0 at the end
|---------|-------------------|---------------------------------------------------|
      LINE INDEX
      ----------
    23    |                 0 | Records
    24    |                 2 | Words      No line index in this format
          |                   |
|---------|-------------------|---------------------------------------------------|
      IMAGE INFORMATION
      -----------------
    25    |                 0 | Records   length of image information
    26    |                13 | Words
          |                   |
|---------|-------------------|---------------------------------------------------|
AN201512.BI                      3-FEB-87                      PAGE  10

|---------|-------------------|-------------------------------------------------|
| WORDNO. |      CONTENT      |                     COMMENT                     |
|---------|-------------------|-------------------------------------------------|
|  27-  27| 0F E0             |0000111111100000                                 |
|  28-  28| 38 30             |0011100000110000                                 |
|  29-  29| 70 78             |0111000001111000                                 |
|  30-  30| E0 30             |1110000000110000                                 |
|  31-  31| E0 00             |1110000000000000                                 |
|  32-  32| E0 00             |1110000000000000                                 |
|  33-  33| E0 00             |1110000000000000                                 |
|  34-  34| E0 00             |1110000000000000                                 |
|  35-  35| 70 08             |0111000000001000                                 |
|  36-  36| 38 30             |0011100000110000                                 |
|  37-  37| 0F C0             |0000111111000000                                 |
|         |                   |                                                 |
|---------|-------------------|-------------------------------------------------|
|
|
|                              GRAND TOTAL
|                              -----------
|                                                   WORDS          KBYTES
|                                                   -----          ------
|   Length of font:                                  6317          12.634
|   Length of font header:                            484           0.968
|   Length of all character headers:                 3240           6.480
|   Length of total image information:               2593           5.186
|
|             DIGITIZATIONS                            NUMBER
|             -------------                            ------
|             Lines:                                     1917
|             Total of bytes:                            4606
|             -------------------------------------------------
|             Characters:                                 135
|             Records (a 2048 words):                       4
|             -------------------------------------------------
|             Raster (grid):                         32 X  24
|             -------------------------------------------------
|             Digitizations per line:                    2.40
|             Lines per character:                         14
|             Image information per character:             38 bytes
|
|                                                                               |
---------------------------------------------------------------------------------
```

Appendix Q
Description of the GS format

1. Structure of a GS font

The structure of a GS font is as described in appendix G with an extended structure as in appendix K.
In the identification for a font (word number 50) the number of gray tones is coded:
G1 for 2 bit, G2 for 3 bit, G3 for 4 bit, G4 for 8 bit etc.

2. Description of the GS format

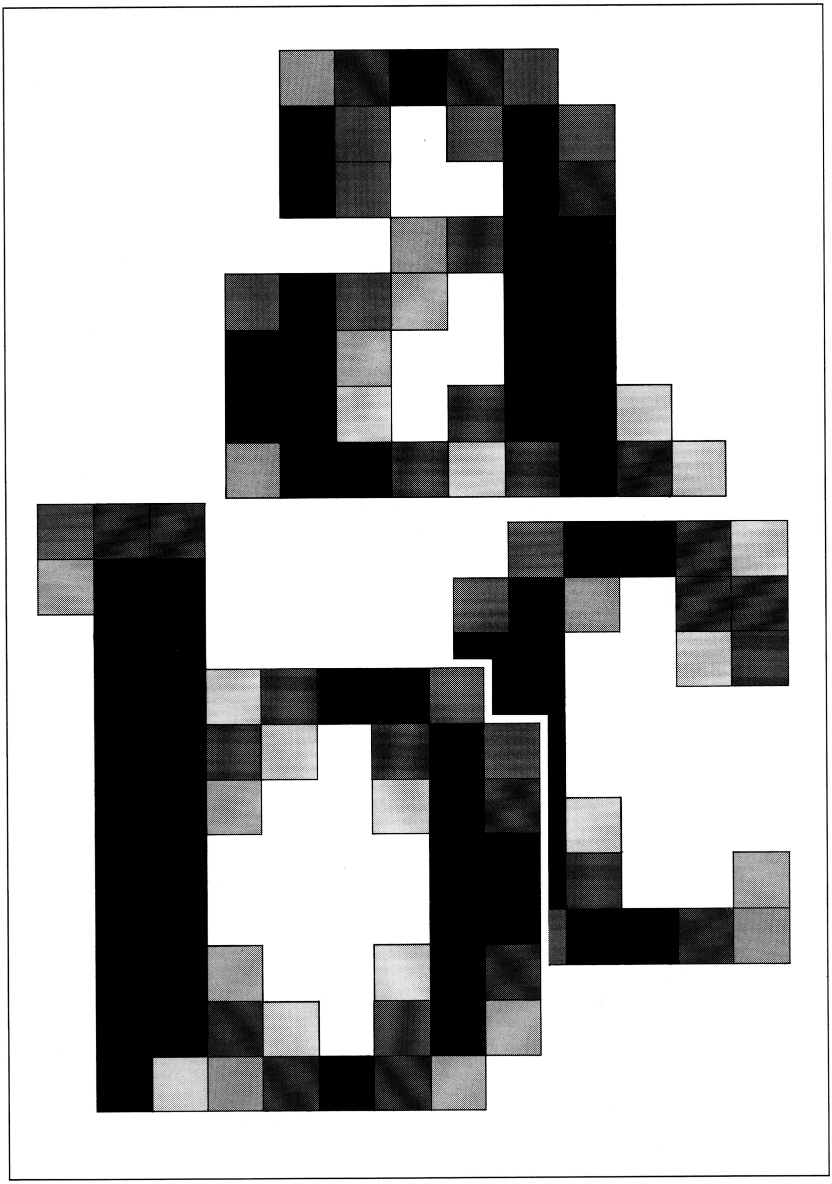
The **gray scale format** was designed to describe points which are not only black or white but also half tone. In the case of a 4 bit coding with linear interpretation for gray the following gray scales are possible:

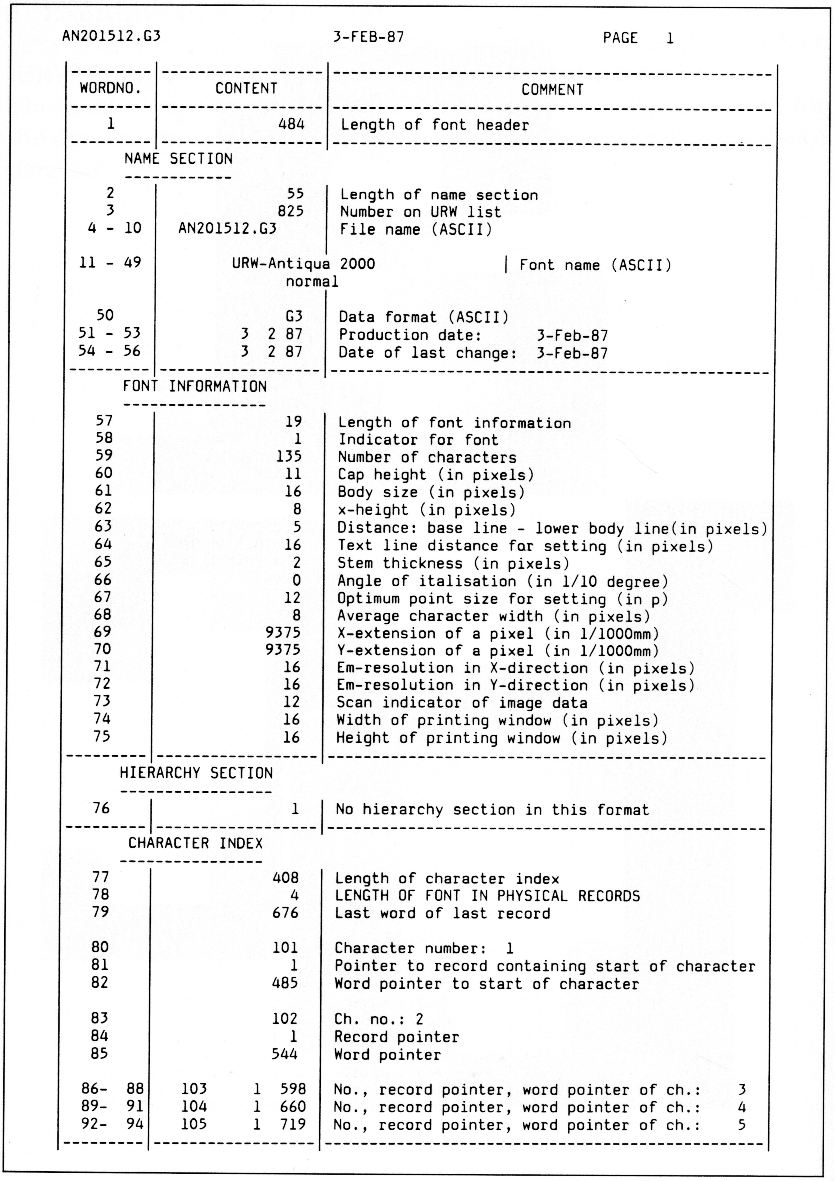
Hexadecimal 4 bit value	Black fraction in %	Comment
0	0	white
1	7	.
2	16	light
.	.	.
.	.	.
.	.	.
E	93	dark
F	100	black

The four bits are recorded as a halfbyte and written corresponding to the BI format conventions. With the GS format however, two pixels already form one byte, and we therefore expect four times more data for an equivalent grid resolution.
One byte is considered as one digitization.

3. Example of a GS format

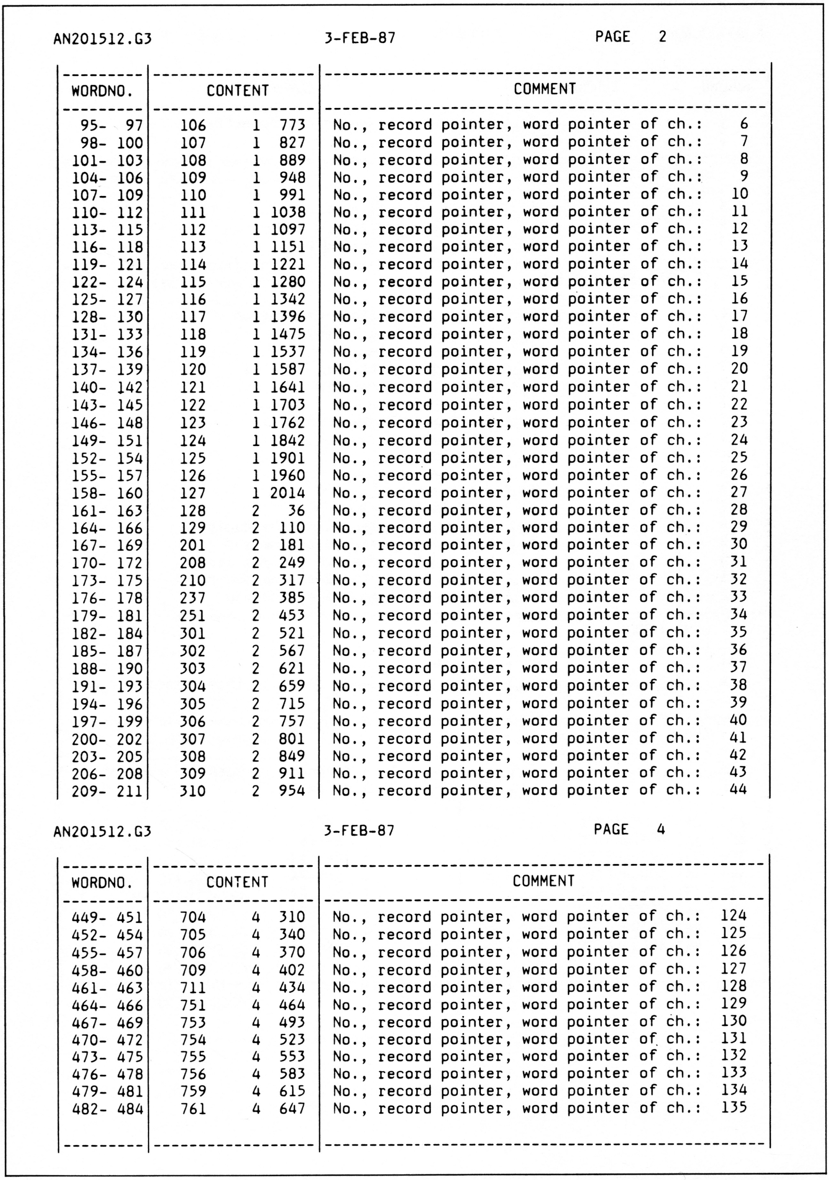
First of all we represent the lower case letters a, b, c of the typeface "URW Antiqua 2015 normal", as graymaps of a 4 bit coding.
The scan identification is 12 (laser printer). The raster is 16 × 16 for the em square. Subsequently, the type font format is reproduced as a data list.





```
AN201512.G3                          3-FEB-87                          PAGE    1

 |---------|------------------|----------------------------------------------|
 | WORDNO. |     CONTENT      |                   COMMENT                    |
 |---------|------------------|----------------------------------------------|
 |    1    |              484 | Length of font header                        |
 |---------|------------------|----------------------------------------------|
         NAME SECTION
         ------------
      2   |               55  | Length of name section
      3   |              825  | Number on URW list
  4 - 10  |   AN201512.G3     | File name (ASCII)
          |                   |
 11 - 49  |         URW-Antiqua 2000            | Font name (ASCII)
          |               normal
          |                   |
     50   |                G3 | Data format (ASCII)
 51 - 53  |           3  2 87 | Production date:       3-Feb-87
 54 - 56  |           3  2 87 | Date of last change:   3-Feb-87
 ---------|------------------|----------------------------------------------
         FONT INFORMATION
         ----------------
     57   |                19 | Length of font information
     58   |                 1 | Indicator for font
     59   |               135 | Number of characters
     60   |                11 | Cap height (in pixels)
     61   |                16 | Body size (in pixels)
     62   |                 8 | x-height (in pixels)
     63   |                 5 | Distance: base line - lower body line(in pixels)
     64   |                16 | Text line distance for setting (in pixels)
     65   |                 2 | Stem thickness (in pixels)
     66   |                 0 | Angle of italisation (in 1/10 degree)
     67   |                12 | Optimum point size for setting (in p)
     68   |                 8 | Average character width (in pixels)
     69   |              9375 | X-extension of a pixel (in 1/1000mm)
     70   |              9375 | Y-extension of a pixel (in 1/1000mm)
     71   |                16 | Em-resolution in X-direction (in pixels)
     72   |                16 | Em-resolution in Y-direction (in pixels)
     73   |                12 | Scan indicator of image data
     74   |                16 | Width of printing window (in pixels)
     75   |                16 | Height of printing window (in pixels)
 ---------|------------------|----------------------------------------------
         HIERARCHY SECTION
         -----------------
     76   |                 1 | No hierarchy section in this format
 ---------|------------------|----------------------------------------------
         CHARACTER INDEX
         ---------------
     77   |               408 | Length of character index
     78   |                 4 | LENGTH OF FONT IN PHYSICAL RECORDS
     79   |               676 | Last word of last record
          |                   |
     80   |               101 | Character number:  1
     81   |                 1 | Pointer to record containing start of character
     82   |               485 | Word pointer to start of character
          |                   |
     83   |               102 | Ch. no.: 2
     84   |                 1 | Record pointer
     85   |               544 | Word pointer
          |                   |
  86- 88  |   103      1  598 | No., record pointer, word pointer of ch.:    3
  89- 91  |   104      1  660 | No., record pointer, word pointer of ch.:    4
  92- 94  |   105      1  719 | No., record pointer, word pointer of ch.:    5
 |---------|------------------|----------------------------------------------|
```



```
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|---------|------------------|----------------------------------------------------|
| WORDNO. |     CONTENT      |                       COMMENT                      |
|---------|------------------|----------------------------------------------------|
|   95- 97|   106      1  773| No., record pointer, word pointer of ch.:      6   |
|  98- 100|   107      1  827| No., record pointer, word pointer of ch.:      7   |
| 101- 103|   108      1  889| No., record pointer, word pointer of ch.:      8   |
| 104- 106|   109      1  948| No., record pointer, word pointer of ch.:      9   |
| 107- 109|   110      1  991| No., record pointer, word pointer of ch.:     10   |
| 110- 112|   111      1 1038| No., record pointer, word pointer of ch.:     11   |
| 113- 115|   112      1 1097| No., record pointer, word pointer of ch.:     12   |
| 116- 118|   113      1 1151| No., record pointer, word pointer of ch.:     13   |
| 119- 121|   114      1 1221| No., record pointer, word pointer of ch.:     14   |
| 122- 124|   115      1 1280| No., record pointer, word pointer of ch.:     15   |
| 125- 127|   116      1 1342| No., record pointer, word pointer of ch.:     16   |
| 128- 130|   117      1 1396| No., record pointer, word pointer of ch.:     17   |
| 131- 133|   118      1 1475| No., record pointer, word pointer of ch.:     18   |
| 134- 136|   119      1 1537| No., record pointer, word pointer of ch.:     19   |
| 137- 139|   120      1 1587| No., record pointer, word pointer of ch.:     20   |
| 140- 142|   121      1 1641| No., record pointer, word pointer of ch.:     21   |
| 143- 145|   122      1 1703| No., record pointer, word pointer of ch.:     22   |
| 146- 148|   123      1 1762| No., record pointer, word pointer of ch.:     23   |
| 149- 151|   124      1 1842| No., record pointer, word pointer of ch.:     24   |
| 152- 154|   125      1 1901| No., record pointer, word pointer of ch.:     25   |
| 155- 157|   126      1 1960| No., record pointer, word pointer of ch.:     26   |
| 158- 160|   127      1 2014| No., record pointer, word pointer of ch.:     27   |
| 161- 163|   128      2   36| No., record pointer, word pointer of ch.:     28   |
| 164- 166|   129      2  110| No., record pointer, word pointer of ch.:     29   |
| 167- 169|   201      2  181| No., record pointer, word pointer of ch.:     30   |
| 170- 172|   208      2  249| No., record pointer, word pointer of ch.:     31   |
| 173- 175|   210      2  317| No., record pointer, word pointer of ch.:     32   |
| 176- 178|   237      2  385| No., record pointer, word pointer of ch.:     33   |
| 179- 181|   251      2  453| No., record pointer, word pointer of ch.:     34   |
| 182- 184|   301      2  521| No., record pointer, word pointer of ch.:     35   |
| 185- 187|   302      2  567| No., record pointer, word pointer of ch.:     36   |
| 188- 190|   303      2  621| No., record pointer, word pointer of ch.:     37   |
| 191- 193|   304      2  659| No., record pointer, word pointer of ch.:     38   |
| 194- 196|   305      2  715| No., record pointer, word pointer of ch.:     39   |
| 197- 199|   306      2  757| No., record pointer, word pointer of ch.:     40   |
| 200- 202|   307      2  801| No., record pointer, word pointer of ch.:     41   |
| 203- 205|   308      2  849| No., record pointer, word pointer of ch.:     42   |
| 206- 208|   309      2  911| No., record pointer, word pointer of ch.:     43   |
| 209- 211|   310      2  954| No., record pointer, word pointer of ch.:     44   |

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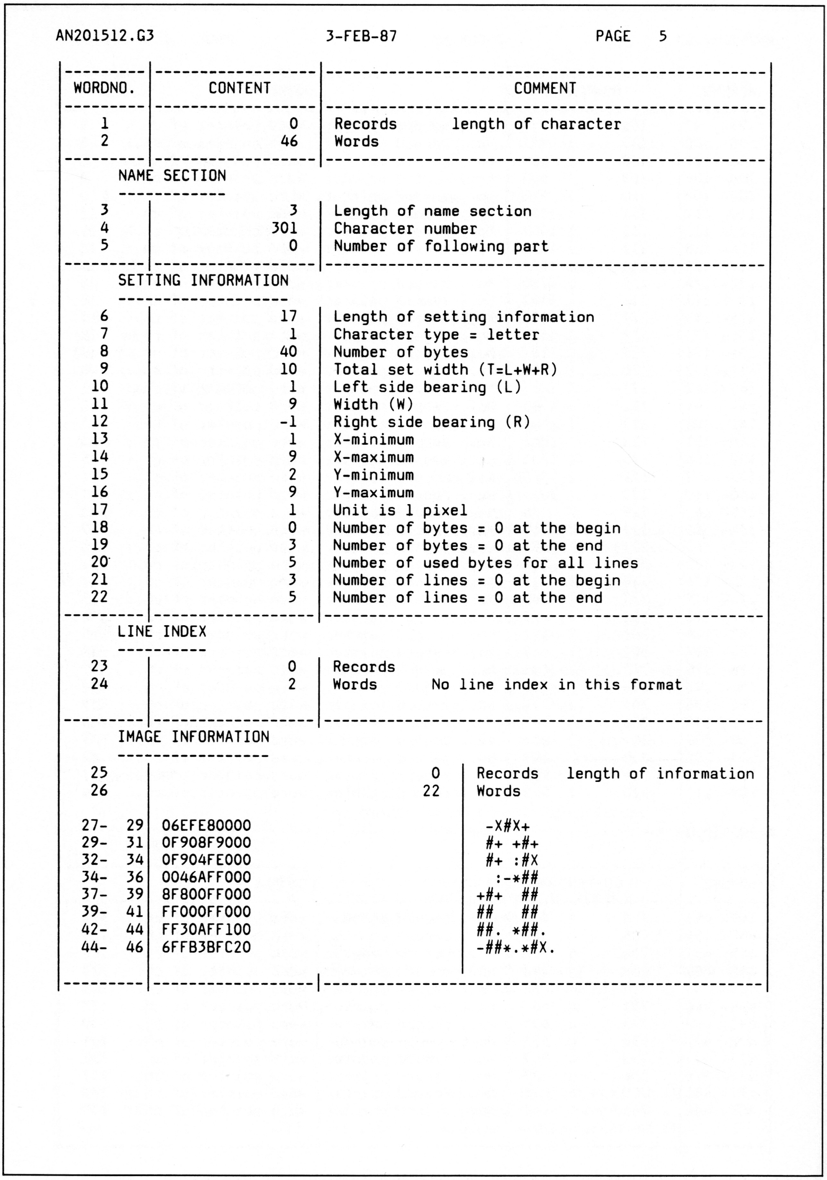
|---------|------------------|----------------------------------------------------|
| WORDNO. |     CONTENT      |                       COMMENT                      |
|---------|------------------|----------------------------------------------------|
| 449- 451|   704      4  310| No., record pointer, word pointer of ch.:    124   |
| 452- 454|   705      4  340| No., record pointer, word pointer of ch.:    125   |
| 455- 457|   706      4  370| No., record pointer, word pointer of ch.:    126   |
| 458- 460|   709      4  402| No., record pointer, word pointer of ch.:    127   |
| 461- 463|   711      4  434| No., record pointer, word pointer of ch.:    128   |
| 464- 466|   751      4  464| No., record pointer, word pointer of ch.:    129   |
| 467- 469|   753      4  493| No., record pointer, word pointer of ch.:    130   |
| 470- 472|   754      4  523| No., record pointer, word pointer of ch.:    131   |
| 473- 475|   755      4  553| No., record pointer, word pointer of ch.:    132   |
| 476- 478|   756      4  583| No., record pointer, word pointer of ch.:    133   |
| 479- 481|   759      4  615| No., record pointer, word pointer of ch.:    134   |
| 482- 484|   761      4  647| No., record pointer, word pointer of ch.:    135   |
|         |                  |                                                    |
|---------|------------------|----------------------------------------------------|
```



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|---------|------------------|--------------------------------------------------|
| WORDNO. |     CONTENT      |                     COMMENT                      |
|---------|------------------|--------------------------------------------------|
|    1    |                 0| Records     length of character                  
|    2    |                46| Words                                            
|---------|------------------|--------------------------------------------------
|      NAME SECTION
|      ------------
|    3    |                 3| Length of name section
|    4    |               301| Character number
|    5    |                 0| Number of following part
|---------|------------------|--------------------------------------------------
|      SETTING INFORMATION
|      -------------------
|    6    |                17| Length of setting information
|    7    |                 1| Character type = letter
|    8    |                40| Number of bytes
|    9    |                10| Total set width (T=L+W+R)
|   10    |                 1| Left side bearing (L)
|   11    |                 9| Width (W)
|   12    |                -1| Right side bearing (R)
|   13    |                 1| X-minimum
|   14    |                 9| X-maximum
|   15    |                 2| Y-minimum
|   16    |                 9| Y-maximum
|   17    |                 1| Unit is 1 pixel
|   18    |                 0| Number of bytes = 0 at the begin
|   19    |                 3| Number of bytes = 0 at the end
|   20    |                 5| Number of used bytes for all lines
|   21    |                 3| Number of lines = 0 at the begin
|   22    |                 5| Number of lines = 0 at the end
|---------|------------------|--------------------------------------------------
|      LINE INDEX
|      ----------
|   23    |                 0| Records
|   24    |                 2| Words      No line index in this format
|         |                  |
|---------|------------------|--------------------------------------------------
|      IMAGE INFORMATION
|      -----------------
|   25    |                                 0 | Records   length of information
|   26    |                                22 | Words
|         |                                   |
|  27-  29| 06EFE80000                        |  -X#X+
|  29-  31| 0F908F9000                        |  #+ +#+
|  32-  34| 0F904FE000                        |  #+ :#X
|  34-  36| 0046AFF000                        |   :-*##
|  37-  39| 8F800FF000                        | +#+  ##
|  39-  41| FF000FF000                        | ##   ##
|  42-  44| FF30AFF100                        | ##. *##.
|  44-  46| 6FFB3BFC20                        | -##*.*#X.
|         |                                   |
|---------|------------------|--------------------------------------------------|
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|---------|------------------|--------------------------------------------------|
 WORDNO.  |     CONTENT      |                    COMMENT
 ---------|------------------|--------------------------------------------------
     1    |                 0| Records      length of character
     2    |                54| Words
 ---------|------------------|--------------------------------------------------
      NAME SECTION
      ------------
     3    |                 3| Length of name section
     4    |               302| Character number
     5    |                 0| Number of following part
 ---------|------------------|--------------------------------------------------
      SETTING INFORMATION
      -------------------
     6    |                17| Length of setting information
     7    |                 1| Character type = letter
     8    |                55| Number of bytes
     9    |                10| Total set width (T=L+W+R)
    10    |                 0| Left side bearing (L)
    11    |                 9| Width (W)
    12    |                 1| Right side bearing (R)
    13    |                 1| X-minimum
    14    |                 9| X-maximum
    15    |                 2| Y-minimum
    16    |                12| Y-maximum
    17    |                 1| Unit is 1 pixel
    18    |                 0| Number of bytes = 0 at the begin
    19    |                 3| Number of bytes = 0 at the end
    20    |                 5| Number of used bytes for all lines
    21    |                 0| Number of lines = 0 at the begin
    22    |                 5| Number of lines = 0 at the end
 ---------|------------------|--------------------------------------------------
      LINE INDEX
      ----------
    23    |                 0| Records
    24    |                 2| Words      No line index in this format
          |                  |
 ---------|------------------|--------------------------------------------------
      IMAGE INFORMATION
      -----------------
    25    |                                 0 | Records   length of information
    26    |                                30 | Words
          |                                   |
   27-  29| 9CE0000000                        | +XX
   29-  31| 4FF0000000                        | :##
   32-  34| 0FF0000000                        |  ##
   34-  36| 0FF1BFF900                        |  ##.*##+
   37-  39| 0FFA20AF80                        |  ##*. *#+
   39-  41| 0FF5001FE0                        |  ##:  .#X
   42-  44| 0FF0000FF0                        |  ##    ##
   44-  46| 0FF0000FF0                        |  ##    ##
   47-  49| 0FF5001FE0                        |  ##:  .#X
   49-  51| 0FFD20AF50                        |  ##X. *#:
   52-  54| 0F37EFE500                        |  #.-X#X:
          |                                   |
|---------|------------------|--------------------------------------------------|
```

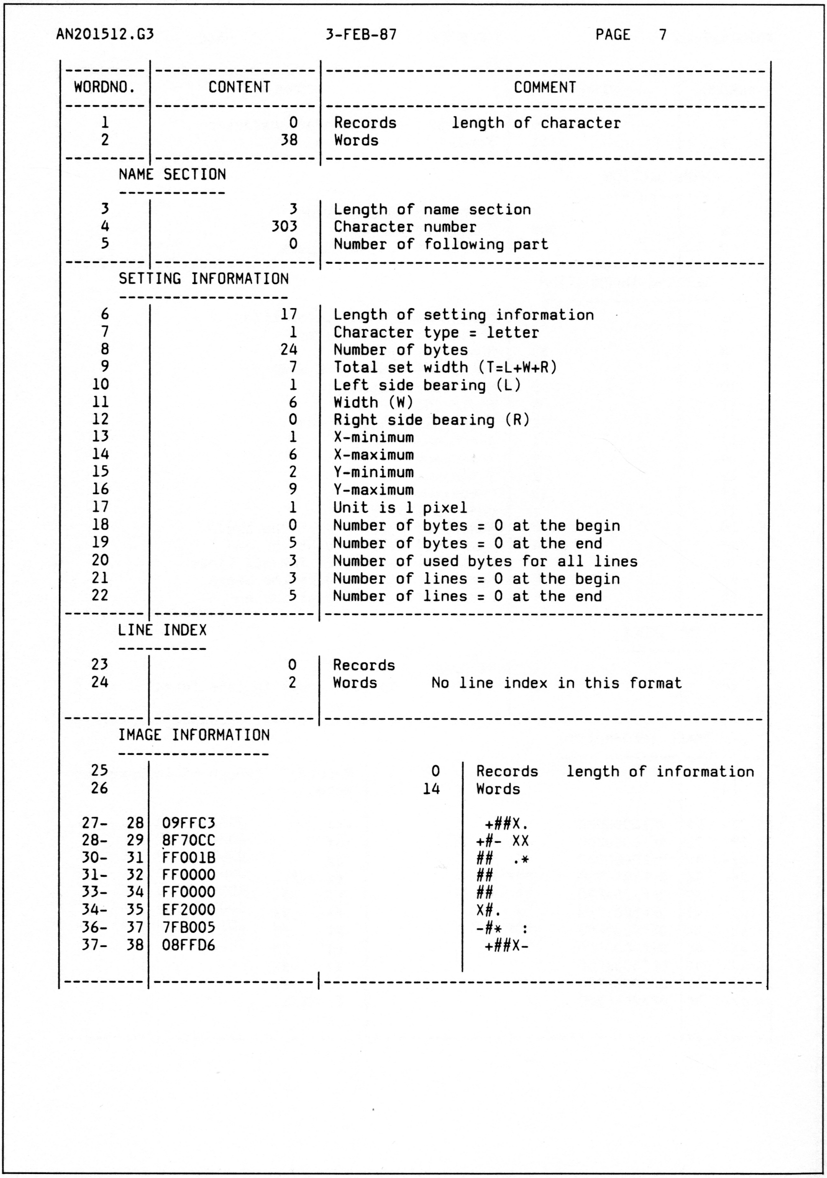

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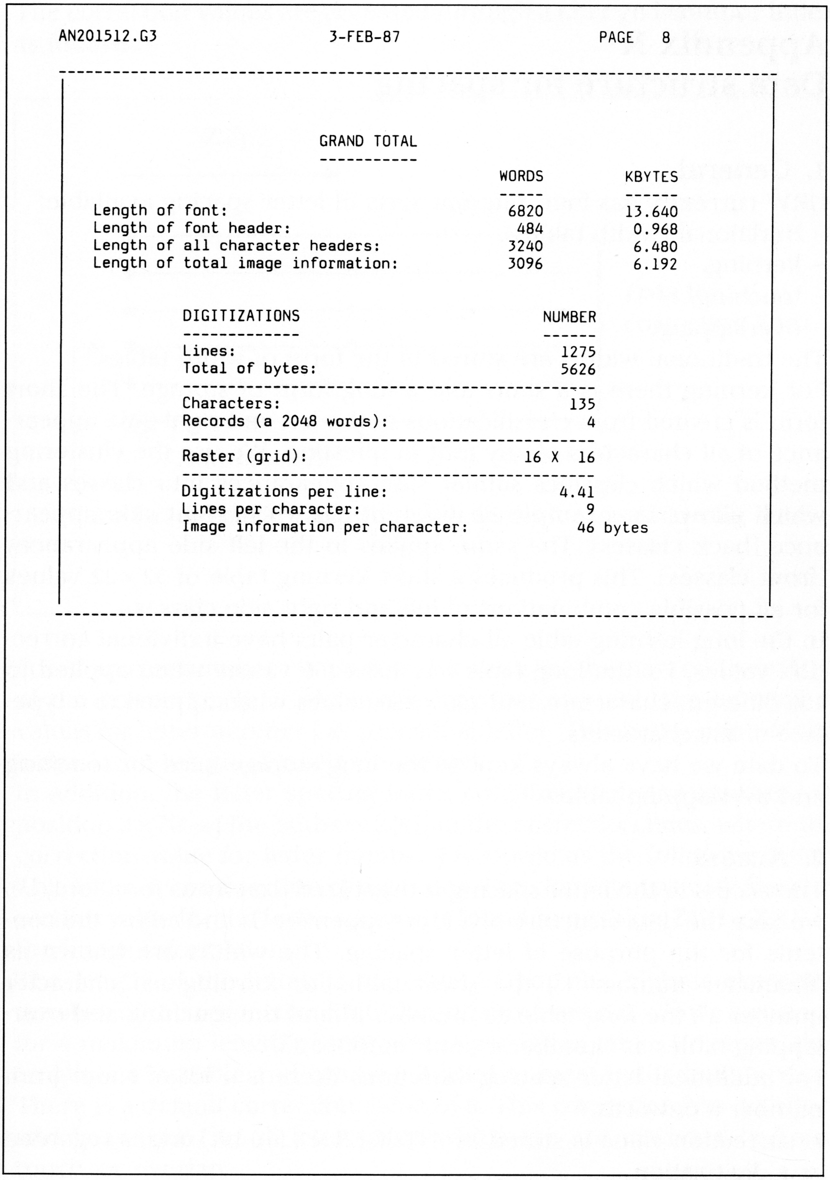
|---------|------------------|----------------------------------------------|
 WORDNO.         CONTENT                           COMMENT
 ---------|------------------|----------------------------------------------
     1    |                 0| Records      length of character
     2    |                38| Words
 ---------|------------------|----------------------------------------------
       NAME SECTION
       ------------
     3    |                 3| Length of name section
     4    |               303| Character number
     5    |                 0| Number of following part
 ---------|------------------|----------------------------------------------
       SETTING INFORMATION
       -------------------
     6    |                17| Length of setting information
     7    |                 1| Character type = letter
     8    |                24| Number of bytes
     9    |                 7| Total set width (T=L+W+R)
    10    |                 1| Left side bearing (L)
    11    |                 6| Width (W)
    12    |                 0| Right side bearing (R)
    13    |                 1| X-minimum
    14    |                 6| X-maximum
    15    |                 2| Y-minimum
    16    |                 9| Y-maximum
    17    |                 1| Unit is 1 pixel
    18    |                 0| Number of bytes = 0 at the begin
    19    |                 5| Number of bytes = 0 at the end
    20    |                 3| Number of used bytes for all lines
    21    |                 3| Number of lines = 0 at the begin
    22    |                 5| Number of lines = 0 at the end
 ---------|------------------|----------------------------------------------
       LINE INDEX
       ----------
    23    |                 0| Records
    24    |                 2| Words      No line index in this format
          |                  |
 ---------|------------------|----------------------------------------------
       IMAGE INFORMATION
       -----------------
    25    |                                0 | Records   length of information
    26    |                               14 | Words
          |                                  |
   27-  28| 09FFC3                           |  +##X.
   28-  29| 8F70CC                           | +#- XX
   30-  31| FF001B                           | ##   .*
   31-  32| FF0000                           | ##
   33-  34| FF0000                           | ##
   34-  35| EF2000                           | X#.
   36-  37| 7FB005                           | -#*   :
   37-  38| 08FFD6                           |  +##X-
          |                                  |
|---------|------------------|----------------------------------------------|
```



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 ---------------------------------------------------------------------
|                                                                     |
|                                                                     |
|                         GRAND TOTAL                                 |
|                         -----------                                 |
|                                          WORDS        KBYTES        |
|                                          -----        ------        |
|  Length of font:                         6820        13.640        |
|  Length of font header:                   484         0.968        |
|  Length of all character headers:        3240         6.480        |
|  Length of total image information:      3096         6.192        |
|                                                                     |
|         DIGITIZATIONS                       NUMBER                  |
|         -------------                       ------                  |
|         Lines:                                1275                  |
|         Total of bytes:                       5626                  |
|         ------------------------------------------                  |
|         Characters:                            135                  |
|         Records (a 2048 words):                  4                  |
|         ------------------------------------------                  |
|         Raster (grid):                     16 X 16                  |
|         ------------------------------------------                  |
|         Digitizations per line:               4.41                  |
|         Lines per character:                     9                  |
|         Image information per character:        46 bytes            |
|                                                                     |
|                                                                     |
 ---------------------------------------------------------------------
```

Appendix R
Data structure for spacing

1. General

URW currently has four different sorts of letter spacing available:
- traditional (width tables),
- kerning,
- touching,
- overlapping.

The traditional widths are stored in the form of width tables.

For kerning there is a short and a long form of storage. The short form is created from classifications of the left and right side appearance of all characters of any font in question. We use the clustering method which classifies similar side appearances into classes and which allows for example 32 different classes of right side appearance (back classes). The same applies to the left side appearances (front classes). This produces a short kerning table of 32 × 32 values for all possible combinations of left and right side classes.

In the long kerning table all character pairs have individual correction values, i.e. the long table has 100 × 100 values when applied to 100 different characters, and 250 × 250 values when applied to a typeface of 250 characters.

To date we have always kept to the long storage form for touching and overlapping tables.

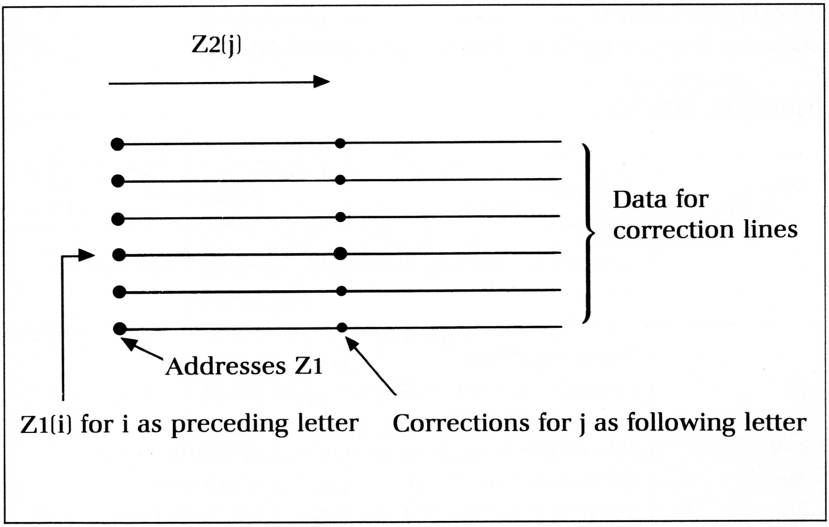
2. Access

The access to the letter spacing is organized exactly as for a font, i.e. we take the data structure of a font (appendix G) and adjust the contents for the purpose of letter spacing. The widths are known as "character number 1", the short table for kerning as "character number 2", the long table as "number 3" and the touching and overlapping tables as "number 4" and "number 5".

For additional letter spacing variations there is a lot of room from number 6 onwards.

A correction value is stored as INTEGER × 2 (16 bit) and is regarded as a digitization.

The correction values are accessed through a changed contour index as follows:


Z2(j)
Data for correction lines
Addresses Z1
Z1(i) for i as preceding letter
Corrections for j as following letter

For character number i in position i it contains the start address Z1(i) of the correction line (old image information) with the correction values for letter number i as preceding letter. This first section of the index has a length of 2 × N4 (in words).

In addition, the letter spacing index contains for letter number j in position 2 × N4 + j the address Z2(j) in the correction lines, where the correction value for letter number j is stored as the following letter. This is the second section of the index. For character pair (ij) the correction value for the letter spacing is found in position Z1(i) + Z2(j) in the image information.

The length of the index is dependent upon the highest character number of the respective font. Our current concept allows for space for a maximum length of 1000 places per index table. However, this length is a variable and can be adjusted to meet individual needs.

There is a default correction value of 0. This correction has no effect and is assigned to all letter pairs which are not intended to kern, touch, or overlap.

3. Description of the letter spacing header

In this appendix we wish to describe the letter spacing and use a changed font header. The data records for the tables follow in appendices S, T, U and V.

Data carriers are as described in appendix G, point 1.

Spacing header

Word	Meaning	Comment
1	Length of spacing header in words	$=1+I+J+L+M$
	Name section	
2	Length of name section	(I)
3	Number on URW list	
4–9	File name	6 words
10–49	Font name in ASCII	40 words
50	Format identification of data	SP (spacing)
51–53	Production date	3 words
54–56	Date of last change	e.g. 16,6,85 for 16th of June 1985. Currently (1985) I has the value 55 at URW.
	Spacing information	
I+2	Length of spacing data in words	(J)
I+3	Identification of spacing	$=3$
I+4	Number of tables	Currently $=5$
I+5	Cap height	in units At URW currently (1985) J has the value 4.

Word	Meaning	Comment
	Hierarchy section	
I+J+2	Length of hierarchy	(L) =1 for spacing
	Table index	
I+J+L+2	Length of table index	(M)
I+J+L+3	Pointer to last written physical record (=**length of spacing in physical records**)	Current length of spacing data
I+J+L+4	Pointer to last written word of last record	
I+J+L+5	Number of first table	Widths
I+J+L+6	Record pointer in the spacing which contains the start of the first table	
I+J+L+7	Pointer to the first word used in this record	
I+J+L+8	Number	Short kerning (clustering)
I+J+L+9	Record pointer	
I+J+L+10	Word pointer	
I+J+L+11	Number	Long kerning
I+J+L+12	Record pointer	
I+J+L+13	Word pointer	
I+J+L+14	Number	Touching
I+J+L+15	Record pointer	
I+J+L+16	Word pointer	
I+J+L+17	Number	Overlapping
I+J+L+18	Record pointer	
I+J+L+19	Word pointer	

An adjustment of the letter spacing for all data records can only be carried out together with the associated character number list (see appendix B) of the respective font.

Appendix S
Width table

The width tables could be compressed because one does not actually need access to a matrix, but rather to a simple array. We have decided to ignore this exception. For this reason the width table in letter spacing (see appendix R) has the following structure shown below. An example is reproduced at the end of appendix T, section 4.

1. Width record

Word	Meaning	Comment
	Length of width record	$2+N1+N2+N3+M$
1	in records	
2	in words	
	Name section	
3	Length of name section	N1 (currently $=3$)
4	Number	$=1$ (width)
5	Following part number	$=0$ (currently)
	Record information	
$N1+3$	Length of record information	N2 (currently $=3$)
$N1+4$	Number of widths	
$N1+5$	Unit size	according to font format
	Spacing index	
	Length of letter spacing index	$N3=2+N4\times 3$
$N1+N2+3$	in records	
$N1+N2+4$	in words	

Word	Meaning	Comment
N1+N2+5 N1+N2+6	Record and word pointer of width of character number 1	The addresses are counted relative to the start of spacing information.
N1+N2+7 N1+N2+8	Record and word pointer of width of character number 2	N4 entries for width line ≙ Addresses Z1(i) as per appendix R
. . .	. . .	
N1+N2+4 +N4 × 2	Word pointer of width of highest character number of font	
N1+N2+5 +N4 × 2	0	N4 entries for width lines ≙ Addresses Z2(j) as per appendix R, all N4 entries are given the value 0.
	Letter spacing information	
N1+N2+N3	Length of table	M
+3	in records	
+4	in words	
+5	“Width” of the em	Default parameter
+6	Width of first character with no default width	
+7	Width of second character with no default width	
. . .	. . .	
N1+N2 +N3+M+2	Last width	

Thus, to read the width of character i and the next character j from the table we have the following:
Address: =Z1[i]+Z2[j],
Width: =contents [address].
The details of the next character j are then irrelevant. We do however intend to adjust the access to widths, to that of the method for kerning correction values.
An example of a width table record is shown at the end of appendix T, the table is representing traditional widths for the typeface “URW Antiqua 2015 normal”.

Appendix T
Kerning table

There are long and short versions of kerning tables. As already mentioned the short tables are generated by classifying left and right side appearances of characters, and the long tables as kerning corrections for all possible letter pairs of a type font. The short kerning table has the following structure (see also appendix R):

1. Short kerning record

Word	Meaning	Comment
	Length of short kerning record	2 + N1 + N2 + N3 + M
1	in records	
2	in words	
	Name section	
3	Length of name section	N1 (currently = 3)
4	Number	= 2 (short kerning)
5	Following part number	
	Record information	
N1 + 3	Length of record information	N2 (currently = 4)
N1 + 4	Number of correction values	
N1 + 5	Unit size	According to font format
N1 + 6	Number of corresponding long kerning table	
	Spacing index	
	Length of spacing index	N3 = 2 + N4 × 3
N1 + N2 + 3	in records	

Word	Meaning	Comment
N1+N2+4	in words	
N1+N2+5 N1+N2+6	Record and word pointer to correction line for letter pairs, in which the first (front) letter is character number 1.	The addresses are counted relative to start of spacing information.
N1+N2+7 N1+N2+8	Record and word pointer to correction line of the letter pair in which the first (front) letter is character number 2.	N4 entries for correction lines ≙ Addresses Z1(i) as per appendix R
.	.	
.	.	
.	.	
N1+N2+4 +N4×2	Word pointer to correction line of the letter pair in which the last character is in front.	
N1+N2+5 +N4×2	Word pointer to the place in the correction line for letter pairs in which character number 1 is back.	N4 entries for correction lines ≙ Addresses Z2(j) as per appendix R
.	.	
.	.	
.	.	
N1+N2+2 +N3	Last pointer for last character as 2nd (back) letter.	
	Spacing information	
N1+N2+N3	Length of table	M
+3	in records	
+4	in words	
+5	Default correction value line Pair (none,none)	All=0
+6	Pair (none, 1st back class)	1st correction line for "none" character at front.
+7	Pair (none, 2nd back class)	

Word	Meaning	Comment
. . .	. . .	
N1+N2+N3 +N5+5	Correction value for pair 1st front class, "none" character.	=0
+6	Correction value for the pair 1st front class, 1st back class.	2nd correction line
+7	Correction value for the pair 1st front class, 2nd back class.	
. . .	. . .	. . .
2+N1+N2 +N3+M	Correction value for the pair (N5,N5)	Last correction for last front class with last back class.

The correction lines all have a constant length. The N4 entries in the letter spacing index usually include empty indicators (indicators to 1st correction line or the first places of the correction line) for character numbers which do not occur in the font in question or which cause no correction, if they are preceding or following a character. In addition, the classification sometimes makes reference to the same place.

Therefore the lengths of the correction lines are shorter than N4. The following applies:

M = 2 + N5 × N5, where N5 is the number of different classes in a font.

In particular N5 is the line length and has e.g. the value 33 (one default correction plus 32 values for 32 different classes).

An example of a short kerning record at the end of this appendix shows short kerning values for the type "URW Antiqua 2015 normal".

3. Long kerning record

Word	Meaning	Comment
	Length of long kerning record	2 + N1 + N2 + N3 + M
1	in records	
2	in words	
	Name section	
3	Length of name section	N1 (currently = 3)
4	Number	= 3 (long kerning record)
5	Following part number	
	Setting information	
N1 + 3	Length of setting information	N2 (currently = 19)
N1 + 4	Number of lines of correction matrix	N5 (currently)
N1 + 5	Number of columns of correction matrix	N5 (currently)
N1 + 6	Unit size	According to font format
N1 + 7	1st spacing letter	Base upper case
N1 + 8	2nd spacing letter	Base lower case
N1 + 9	Left side bearing	} of 1st base spacing letter
N1 + 10	Right side bearing	
N1 + 11	Left side bearing	} of 2nd base spacing letter
N1 + 12	Right side bearing	
N1 + 13	1st value of minimum distance	on the level of baselines
N1 + 14	2nd value of minimum distance	between baselines (in touching tables = minimum distance for vertical strokes)
N1 + 15	Factor	for compression of white space

Word	Meaning	Comment
N1 + 16	Distance function	= 0 appropriate to geometrical mean = 1 appropriate to arithmetic mean
N1 + 17	Italic angle	in 1/10 degree
N1 + 18	Serif height	in 1/100 mm (are given especially for kerning calculation)
N1 + 19	Cap height	
N1 + 20	x-height	
N1 + 21	Descender length	
	Spacing index	
	Length of spacing	N3 = 2 + N4 × 3
N1 + N2 + 3	in records	
N1 + N2 + 4	in words	
N1 + N2 + 5 N1 + N2 + 6	Record and word pointer to correction line for letter pairs in which the 1st (front) letter is character number 1.	The addresses are counted relative to the start of spacing information.
N1 + N2 + 7 N1 + N2 + 8	Record and word pointer to correction line of the letter pairs in which the 1st (front) letter is character number 2.	N4 entries for correction lines
. . .	. . .	≙ Addresses Z1(i) as per appendix R
N1 + N2 + 4 + N4	Word pointer to correction line of the letter pairs in which the last character is in front.	
N1 + N2 + 5 + N4	Word pointer to the place in correction line for letter pairs in which character number 1 is in 2nd (back) position.	N4 entries for correction lines

Word	Meaning	Comment
.	.	≙
.	.	Addresses Z2(j) as per appendix R
.	.	
2+N1+N2 +N3	Last word pointer for last character as 2nd (back) letter.	
	Spacing information	
N1+N2+N3	Length of table	M
+3	in records	
+4	in words	
+5	Default correction line first entry for pair (none,none)	All=0 1st correction line for “none” character at front
+6	Pair (none, 1st character)	
+7	Pair (none, 2nd character)	
.	.	
.	.	
.	.	2nd correction line
N1+N2+N3 +N5+5	Default correction value	=0 (1st char., none)
+6	2nd word of correction line for first character with no default value as front letter.	Contains correction value for pair formation with first character in front.
+7	1st with 2nd character	
+8	1st with 3rd character	
.	.	
.	.	
.	.	
2+N1+N2 +N3+M	Last with last character	Last correction line

The correction value for the kerning of character i with its successor j is read from the table as follows:
Address: $= Z1(i) + Z2(j)$
Correction: = contents (address)

kerning

unterschneiden

Examples of kerning

4. Examples of spacing records

Here we show tables containing the traditional widths (record 1), the short kerning (record 2), the long kerning (record 3) and widths and bearings (record 6) for the type "URW Antiqua 2015 normal".

```
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|---------|-------------------|---------------------------------------------------|
| Word no |      Content      |                      Meaning                      |
|---------|-------------------|---------------------------------------------------|
|    1    |               76  | Length of spacing header                          |
|---------|-------------------|---------------------------------------------------|
       NAME SECTION
       ------------
     2    |               55  | Length of name section
     3    |                0  | Number on URW list
   4 - 10 |   AN2015.SP       | File name
                              |
  11 - 49                                          | Font name in ASCII

                              |
    50    |               SP  | Format ident of data                              |
  51 - 53 |          6. 2.87  | Production date                                   |
  54 - 56 |         17. 2.87  | Date of last change
|---------|-------------------|---------------------------------------------------|
       SPACING INFORMATION
       -------------------
    57    |                4  | Length of spacing data in words
    58    |                3  | Ident of spacing
    59    |                4  | Number of tables
    60    |            10000  | Cap height (in 1/100 mm)
|---------|-------------------|---------------------------------------------------|
       HIERARCHY SECTION
       -----------------
    61    |                1  | Length of hierarchy
|---------|-------------------|---------------------------------------------------|
       TABLE INDEX
       -----------
    62    |               15  | Length of table index
    63    |               26  | LENGTH OF SPACING IN PHYSICAL RECORDS
    64    |             1453  | Last written word of last record

    65    |                1  | Number of  1. table
    66    |                1  | Pointer to record, which cont. start of table
    67    |             1025  | Pointer to first used word in this record

    68    |                2  | Number of  2. table
    69    |                3  | Record pointer
    70    |               61  | Word pointer

  71-  73 |    3     5     4  | No, record pointer, word pointer f.    3. table
  74-  76 |    6    25    97  | No, record pointer, word pointer f.    4. table
          |                   |
|---------|-------------------|---------------------------------------------------|
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|---------|------------------|-----------------------------------------------|
| Word no |     Content      |                    Meaning                    |
|---------|------------------|-----------------------------------------------|
|    1    |                 1| Records     Length of table                   |
|    2    |              1084| Words                                         |
|---------|------------------|-----------------------------------------------|

      NAME SECTION                                                          |
    3    |                 3| Length of name section                         |
    4    |                 1| Table = widths                                 |
    5    |                 0| Following part number                          |
---------|------------------|-----------------------------------------------|
      RECORD INFORMATION
      ------------------
    6    |                 3| Length of record information
    7    |               120| Number of widths
    8    |                 1| Unit size is 1/100 mm
---------|------------------|-----------------------------------------------
      SPACING INDEX
      -------------
    9    |                 1| Records     Length of spacing index
   10    |               954| Words

  211    |    0            6| Record/wordp. f. width of  101  (abs.    1, 968)
  213    |    0            7| Record/wordp. f. width of  102  (abs.    1, 969)
  215    |    0            8| Record/wordp. f. width of  103  (abs.    1, 970)
  217    |    0            9| Record/wordp. f. width of  104  (abs.    1, 971)
  219    |    0           10| Record/wordp. f. width of  105  (abs.    1, 972)
  221    |    0           11| Record/wordp. f. width of  106  (abs.    1, 973)
  223    |    0           12| Record/wordp. f. width of  107  (abs.    1, 974)
  225    |    0            4| Record/wordp. f. width of  108  (abs.    1, 966)
  227    |    0           13| Record/wordp. f. width of  109  (abs.    1, 975)
  229    |    0           14| Record/wordp. f. width of  110  (abs.    1, 976)
  231    |    0           15| Record/wordp. f. width of  111  (abs.    1, 977)
  233    |    0           16| Record/wordp. f. width of  112  (abs.    1, 978)
  235    |    0           17| Record/wordp. f. width of  113  (abs.    1, 979)
  237    |    0           18| Record/wordp. f. width of  114  (abs.    1, 980)
  239    |    0           19| Record/wordp. f. width of  115  (abs.    1, 981)
  241    |    0           20| Record/wordp. f. width of  116  (abs.    1, 982)
  243    |    0           21| Record/wordp. f. width of  117  (abs.    1, 983)
  245    |    0           22| Record/wordp. f. width of  118  (abs.    1, 984)
  247    |    0           23| Record/wordp. f. width of  119  (abs.    1, 985)
  249    |    0           24| Record/wordp. f. width of  120  (abs.    1, 986)
  251    |    0           25| Record/wordp. f. width of  121  (abs.    1, 987)
  253    |    0           26| Record/wordp. f. width of  122  (abs.    1, 988)
  255    |    0           27| Record/wordp. f. width of  123  (abs.    1, 989)
  257    |    0           28| Record/wordp. f. width of  124  (abs.    1, 990)
  259    |    0           29| Record/wordp. f. width of  125  (abs.    1, 991)
  261    |    0           30| Record/wordp. f. width of  126  (abs.    1, 992)
  263    |    0           31| Record/wordp. f. width of  127  (abs.    1, 993)
  265    |    0           32| Record/wordp. f. width of  128  (abs.    1, 994)
  267    |    0           33| Record/wordp. f. width of  129  (abs.    1, 995)
  411    |    0           34| Record/wordp. f. width of  201  (abs.    1, 996)
  425    |    0           35| Record/wordp. f. width of  208  (abs.    1, 997)
  429    |    0           36| Record/wordp. f. width of  210  (abs.    1, 998)
  483    |    0           37| Record/wordp. f. width of  237  (abs.    1, 999)
  511    |    0           38| Record/wordp. f. width of  251  (abs.    1,1000)
  611    |    0           39| Record/wordp. f. width of  301  (abs.    1,1001)
  613    |    0           40| Record/wordp. f. width of  302  (abs.    1,1002)
  615    |    0           41| Record/wordp. f. width of  303  (abs.    1,1003)
  617    |    0           42| Record/wordp. f. width of  304  (abs.    1,1004)
|---------|------------------|-----------------------------------------------|
```

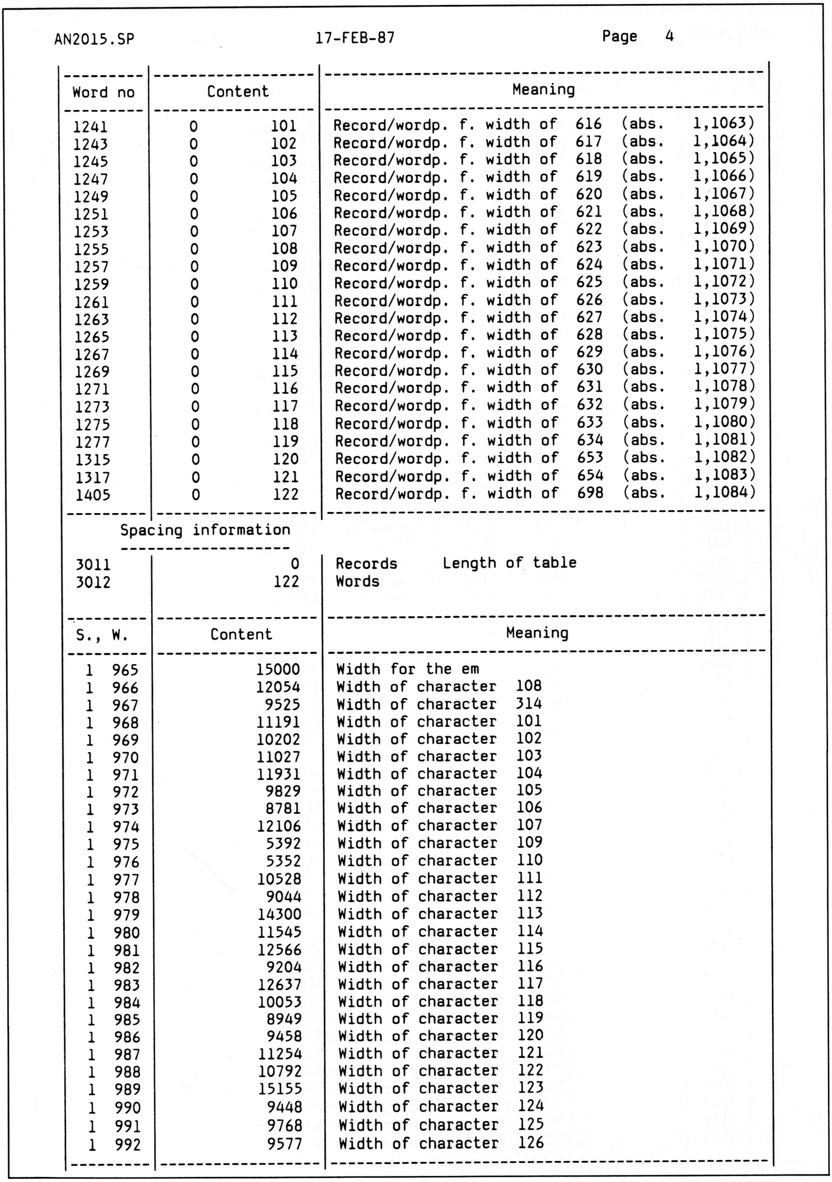

```
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 ---------   -----------------   ---------------------------------------------
 Word no         Content                          Meaning
 ---------   -----------------   ---------------------------------------------
 1241          0          101     Record/wordp. f. width of  616  (abs.   1,1063)
 1243          0          102     Record/wordp. f. width of  617  (abs.   1,1064)
 1245          0          103     Record/wordp. f. width of  618  (abs.   1,1065)
 1247          0          104     Record/wordp. f. width of  619  (abs.   1,1066)
 1249          0          105     Record/wordp. f. width of  620  (abs.   1,1067)
 1251          0          106     Record/wordp. f. width of  621  (abs.   1,1068)
 1253          0          107     Record/wordp. f. width of  622  (abs.   1,1069)
 1255          0          108     Record/wordp. f. width of  623  (abs.   1,1070)
 1257          0          109     Record/wordp. f. width of  624  (abs.   1,1071)
 1259          0          110     Record/wordp. f. width of  625  (abs.   1,1072)
 1261          0          111     Record/wordp. f. width of  626  (abs.   1,1073)
 1263          0          112     Record/wordp. f. width of  627  (abs.   1,1074)
 1265          0          113     Record/wordp. f. width of  628  (abs.   1,1075)
 1267          0          114     Record/wordp. f. width of  629  (abs.   1,1076)
 1269          0          115     Record/wordp. f. width of  630  (abs.   1,1077)
 1271          0          116     Record/wordp. f. width of  631  (abs.   1,1078)
 1273          0          117     Record/wordp. f. width of  632  (abs.   1,1079)
 1275          0          118     Record/wordp. f. width of  633  (abs.   1,1080)
 1277          0          119     Record/wordp. f. width of  634  (abs.   1,1081)
 1315          0          120     Record/wordp. f. width of  653  (abs.   1,1082)
 1317          0          121     Record/wordp. f. width of  654  (abs.   1,1083)
 1405          0          122     Record/wordp. f. width of  698  (abs.   1,1084)
 ---------   -----------------   ---------------------------------------------
       Spacing information
       -------------------
 3011                       0     Records     Length of table
 3012                     122     Words

 ---------   -----------------   ---------------------------------------------
 S., W.          Content                         Meaning
 ---------   -----------------   ---------------------------------------------
   1  965               15000     Width for the em
   1  966               12054     Width of character  108
   1  967                9525     Width of character  314
   1  968               11191     Width of character  101
   1  969               10202     Width of character  102
   1  970               11027     Width of character  103
   1  971               11931     Width of character  104
   1  972                9829     Width of character  105
   1  973                8781     Width of character  106
   1  974               12106     Width of character  107
   1  975                5392     Width of character  109
   1  976                5352     Width of character  110
   1  977               10528     Width of character  111
   1  978                9044     Width of character  112
   1  979               14300     Width of character  113
   1  980               11545     Width of character  114
   1  981               12566     Width of character  115
   1  982                9204     Width of character  116
   1  983               12637     Width of character  117
   1  984               10053     Width of character  118
   1  985                8949     Width of character  119
   1  986                9458     Width of character  120
   1  987               11254     Width of character  121
   1  988               10792     Width of character  122
   1  989               15155     Width of character  123
   1  990                9448     Width of character  124
   1  991                9768     Width of character  125
   1  992                9577     Width of character  126
 ---------   -----------------   ---------------------------------------------
```

```
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 ---------  ------------------  ----------------------------------------------
 S., W.          Content                            Meaning
 ---------  ------------------  ----------------------------------------------
  1  993             13903      Width of character  127
  1  994             15445      Width of character  128
  1  995             12614      Width of character  129
  1  996             11241      Width of character  201
  1  997             11191      Width of character  208
  1  998             11027      Width of character  210
  1  999             12566      Width of character  237
  1 1000             11254      Width of character  251
  1 1001              7710      Width of character  301
  1 1002              9637      Width of character  302
  1 1003              7407      Width of character  303
  1 1004              9475      Width of character  304
  1 1005              8141      Width of character  305
  1 1006              4421      Width of character  306
  1 1007              7569      Width of character  307
  1 1008              9667      Width of character  308
  1 1009              4369      Width of character  309
  1 1010              4051      Width of character  310
  1 1011              8877      Width of character  311
  1 1012              4400      Width of character  312
  1 1013             14511      Width of character  313
  1 1014              9004      Width of character  315
  1 1015              9426      Width of character  316
  1 1016              9521      Width of character  317
  1 1017              6154      Width of character  318
  1 1018              6984      Width of character  319
  1 1019              4994      Width of character  320
  1 1020              9303      Width of character  321
  1 1021              8377      Width of character  322
  1 1022             12784      Width of character  323
  1 1023              8058      Width of character  324
  1 1024              7881      Width of character  325
  1 1025              7681      Width of character  326
  1 1026             11845      Width of character  327
  1 1027             13430      Width of character  328
  1 1028              8985      Width of character  329
  1 1029              8788      Width of character  330
  1 1030              7710      Width of character  401
  1 1031              7710      Width of character  408
  1 1032              7395      Width of character  413
  1 1033              8985      Width of character  436
  1 1034              9403      Width of character  449
  1 1035              7500      Width of character  501
  1 1036              7500      Width of character  502
  1 1037              7500      Width of character  503
  1 1038              7500      Width of character  504
  1 1039              7500      Width of character  505
  1 1040              7501      Width of character  506
  1 1041              7500      Width of character  507
  1 1042              8000      Width of character  508
  1 1043              7500      Width of character  509
  1 1044              7500      Width of character  510
  1 1045              9647      Width of character  511
  1 1046              7500      Width of character  512
  1 1047              8000      Width of character  513
  1 1048              3500      Width of character  601
  1 1049              3500      Width of character  602
  1 1050              2185      Width of character  603
  1 1051              7000      Width of character  604
 ---------  ------------------  ----------------------------------------------
```

```
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|---------|------------------|-----------------------------------------------|
  S., W.  |     Content      |                    Meaning
 ---------|------------------|-----------------------------------------------
   1 1052 |             7000 |  Width of character  605
   1 1053 |            10500 |  Width of character  606
   1 1054 |             3500 |  Width of character  607
   1 1055 |             3500 |  Width of character  608
   1 1056 |             3092 |  Width of character  609
   1 1057 |             3192 |  Width of character  610
   1 1058 |             5792 |  Width of character  611
   1 1059 |             5792 |  Width of character  612
   1 1060 |             5700 |  Width of character  613
   1 1061 |             3536 |  Width of character  614
   1 1062 |             3536 |  Width of character  615
   1 1063 |             5482 |  Width of character  616
   1 1064 |             5482 |  Width of character  617
   1 1065 |             5596 |  Width of character  618
   1 1066 |             5596 |  Width of character  619
   1 1067 |             4310 |  Width of character  620
   1 1068 |             4310 |  Width of character  621
   1 1069 |             6095 |  Width of character  622
   1 1070 |             4774 |  Width of character  623
   1 1071 |             5977 |  Width of character  624
   1 1072 |             7957 |  Width of character  625
   1 1073 |             4576 |  Width of character  626
   1 1074 |             4576 |  Width of character  627
   1 1075 |             4500 |  Width of character  628
   1 1076 |             4501 |  Width of character  629
   1 1077 |            11722 |  Width of character  630
   1 1078 |             6973 |  Width of character  631
   1 1079 |             6496 |  Width of character  632
   1 1080 |             6496 |  Width of character  633
   1 1081 |             5374 |  Width of character  634
   1 1082 |             3500 |  Width of character  653
   1 1083 |             3500 |  Width of character  654
   1 1084 |             8120 |  Width of character  698
 ---------|------------------|-----------------------------------------------
|---------|------------------|-----------------------------------------------|
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 |---------|-------------------|---------------------------------------------------|
 | Word no |      Content      |                      Meaning                      |
 |---------|-------------------|---------------------------------------------------|
 |    1    |                  1| Records      Length of table                      |
 |    2    |               1991| Words                                             |
 |---------|-------------------|---------------------------------------------------|

       NAME SECTION                                                                |
      3  |                  3| Length of name section                              |
      4  |                  2| Table = short kerning                               |
      5  |                  0| Following part number                               |
 ---------|-------------------|---------------------------------------------------
       RECORD INFORMATION
       ------------------
      6  |                  5| Length of record information
      7  |                 32| Number of columns of correction matrix
      8  |                 32| Number of lines of correction matrix
      9  |                  1| Unit size is 1/100 mm
     10  |                  3| Number of corresponding long kerning table
 ---------|-------------------|---------------------------------------------------
       SPACING INDEX
       -------------
     11  |                  1| Records      Length of spacing index
     12  |                954| Words

    213  |     0         579 | Record/wordp. f. pairs  101,*    (abs.    1,1543)
    215  |     0         675 | Record/wordp. f. pairs  102,*    (abs.    1,1639)
    217  |     0         387 | Record/wordp. f. pairs  103,*    (abs.    1,1351)
    219  |     0         707 | Record/wordp. f. pairs  104,*    (abs.    1,1671)
    221  |     0         675 | Record/wordp. f. pairs  105,*    (abs.    1,1639)
    223  |     0         419 | Record/wordp. f. pairs  106,*    (abs.    1,1383)
    225  |     0         739 | Record/wordp. f. pairs  107,*    (abs.    1,1703)
    227  |     0         451 | Record/wordp. f. pairs  108,*    (abs.    1,1415)
    229  |     0         451 | Record/wordp. f. pairs  109,*    (abs.    1,1415)
    231  |     0         483 | Record/wordp. f. pairs  110,*    (abs.    1,1447)
    233  |     0         227 | Record/wordp. f. pairs  111,*    (abs.    1,1191)
    235  |     0         131 | Record/wordp. f. pairs  112,*    (abs.    1,1095)
    237  |     0         451 | Record/wordp. f. pairs  113,*    (abs.    1,1415)
    239  |     0         483 | Record/wordp. f. pairs  114,*    (abs.    1,1447)
    241  |     0         707 | Record/wordp. f. pairs  115,*    (abs.    1,1671)
    243  |     0         419 | Record/wordp. f. pairs  116,*    (abs.    1,1383)
    245  |     0         803 | Record/wordp. f. pairs  117,*    (abs.    1,1767)
    247  |     0         835 | Record/wordp. f. pairs  118,*    (abs.    1,1799)
    249  |     0         931 | Record/wordp. f. pairs  119,*    (abs.    1,1895)
    251  |     0         419 | Record/wordp. f. pairs  120,*    (abs.    1,1383)
    253  |     0         483 | Record/wordp. f. pairs  121,*    (abs.    1,1447)
    255  |     0         323 | Record/wordp. f. pairs  122,*    (abs.    1,1287)
    257  |     0         323 | Record/wordp. f. pairs  123,*    (abs.    1,1287)
    259  |     0         227 | Record/wordp. f. pairs  124,*    (abs.    1,1191)
    261  |     0         323 | Record/wordp. f. pairs  125,*    (abs.    1,1287)
    263  |     0         963 | Record/wordp. f. pairs  126,*    (abs.    1,1927)
    265  |     0         675 | Record/wordp. f. pairs  127,*    (abs.    1,1639)
    267  |     0         675 | Record/wordp. f. pairs  128,*    (abs.    1,1639)
    269  |     0         707 | Record/wordp. f. pairs  129,*    (abs.    1,1671)
    413  |     0         579 | Record/wordp. f. pairs  201,*    (abs.    1,1543)
    427  |     0         195 | Record/wordp. f. pairs  208,*    (abs.    1,1159)
    431  |     0         291 | Record/wordp. f. pairs  210,*    (abs.    1,1255)
    485  |     0         707 | Record/wordp. f. pairs  237,*    (abs.    1,1671)
    513  |     0         483 | Record/wordp. f. pairs  251,*    (abs.    1,1447)
    613  |     0          67 | Record/wordp. f. pairs  301,*    (abs.    1,1031)
    615  |     0         163 | Record/wordp. f. pairs  302,*    (abs.    1,1127)
 |---------|-------------------|---------------------------------------------------|
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 --------- ----------------- ---------------------------------------------
  Word no        Content                         Meaning
 --------- ----------------- ---------------------------------------------
  1255       0          419    Record/wordp. f. pairs  622,*  (abs.   1,1383)
  1257       0          547    Record/wordp. f. pairs  623,*  (abs.   1,1511)
  1263       0          547    Record/wordp. f. pairs  626,*  (abs.   1,1511)
  1265       0          547    Record/wordp. f. pairs  627,*  (abs.   1,1511)
  1267       0          547    Record/wordp. f. pairs  628,*  (abs.   1,1511)
  1269       0          547    Record/wordp. f. pairs  629,*  (abs.   1,1511)
  1271       0          547    Record/wordp. f. pairs  630,*  (abs.   1,1511)
  1273       0          547    Record/wordp. f. pairs  631,*  (abs.   1,1511)
  1279       0          643    Record/wordp. f. pairs  634,*  (abs.   1,1607)
  1407       0           99    Record/wordp. f. pairs  698,*  (abs.   1,1063)
  2113                   18    Word pointer for character pairs  *, 101
  2114                    1    Word pointer for character pairs  *, 102
  2115                    2    Word pointer for character pairs  *, 103
  2116                    1    Word pointer for character pairs  *, 104
  2117                    1    Word pointer for character pairs  *, 105
  2118                    1    Word pointer for character pairs  *, 106
  2119                    2    Word pointer for character pairs  *, 107
  2120                    1    Word pointer for character pairs  *, 108
  2121                    1    Word pointer for character pairs  *, 109
  2122                   30    Word pointer for character pairs  *, 110
  2123                    1    Word pointer for character pairs  *, 111
  2124                    1    Word pointer for character pairs  *, 112
  2125                    1    Word pointer for character pairs  *, 113
  2126                    1    Word pointer for character pairs  *, 114
  2127                    2    Word pointer for character pairs  *, 115
  2128                    1    Word pointer for character pairs  *, 116
  2129                    2    Word pointer for character pairs  *, 117
  2130                    1    Word pointer for character pairs  *, 118
  2131                   30    Word pointer for character pairs  *, 119
  2132                   14    Word pointer for character pairs  *, 120
  2133                   22    Word pointer for character pairs  *, 121
  2134                   23    Word pointer for character pairs  *, 122
  2135                   23    Word pointer for character pairs  *, 123
  2136                   24    Word pointer for character pairs  *, 124
  2137                   23    Word pointer for character pairs  *, 125
  2138                    7    Word pointer for character pairs  *, 126
  2139                   18    Word pointer for character pairs  *, 127
  2140                    2    Word pointer for character pairs  *, 128
  2141                    2    Word pointer for character pairs  *, 129
  2213                   18    Word pointer for character pairs  *, 201
  2220                    4    Word pointer for character pairs  *, 208
  2222                    2    Word pointer for character pairs  *, 210
  2249                    2    Word pointer for character pairs  *, 237
  2263                   22    Word pointer for character pairs  *, 251
  2313                   25    Word pointer for character pairs  *, 301
  2314                   16    Word pointer for character pairs  *, 302
  2315                   11    Word pointer for character pairs  *, 303
  2316                   11    Word pointer for character pairs  *, 304
  2317                   11    Word pointer for character pairs  *, 305
  2318                   27    Word pointer for character pairs  *, 306
  2319                   15    Word pointer for character pairs  *, 307
  2320                   16    Word pointer for character pairs  *, 308
  2321                    3    Word pointer for character pairs  *, 309
  2322                   21    Word pointer for character pairs  *, 310
  2323                   16    Word pointer for character pairs  *, 311
  2324                   16    Word pointer for character pairs  *, 312
  2325                   13    Word pointer for character pairs  *, 313
  2326                   13    Word pointer for character pairs  *, 314
  2327                   11    Word pointer for character pairs  *, 315
 --------- ----------------- ---------------------------------------------
```

```
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|---------|------------------|---------------------------------------------
| Word no |     Content      |                   Meaning
|---------|------------------|---------------------------------------------
|      Spacing information
|      -------------------
| 3013    |                0 | Records     Length of table
| 3014    |             1026 | Words
|         |                  |
|----------------|-------------------------------------------------------------
| S., W.  COLUMN |                      CORRECTION VALUE
|----------------|-------------------------------------------------------------
|  1, 967  0-  9 |     0     0     0     0     0     0     0     0     0     0
|         10- 19 |     0     0     0     0     0     0     0     0     0     0
|         20- 29 |     0     0     0     0     0     0     0     0     0     0
|         30- 31 |     0     0
|  1, 999  0-  9 |     0 -1248 -1641 -1740   197 -1787 -1795 -1069 -1141 -2266
|         10- 19 | -2232 -1803 -1569 -1492 -2792 -1435 -1596 -3243   272 -2426
|         20- 29 |  -683 -1025 -1821 -2760  -874 -1305 -2677 -1856 -1598 -1210
|         30- 31 |  -824  -357
|  1,1031  0-  9 |     0 -1255  -946 -1017  -471 -1517  -959 -1206 -1078 -1199
|         10- 19 |  -999  -982  -985 -1015 -1475  -989 -1228 -2086  -444 -1449
|         20- 29 |  -572 -1009 -1378 -1835 -1444  -942  -998  -997 -1412 -1077
|         30- 31 | -1110  -603
|  1,1063  0-  9 |     0 -1257  -907  -987  -823 -1287 -1841 -1167 -2061 -1276
|         10- 19 |  -899  -842  -928 -1014 -1279  -974 -1177 -1416  -813 -2142
|         20- 29 |  -677 -1013 -1222 -1504 -1373  -865  -875  -929 -1243  -991
|         30- 31 |  -999 -1749
|  1,1095  0-  9 |     0 -1258  -911 -1098 -1029 -1246  -346 -1151  -972  -385
|         10- 19 | -1026  -829 -1053 -1091 -2198 -1020 -1221 -2291  -829  -551
|         20- 29 |  -714 -1032 -1207 -1672 -1321  -865 -1029 -1033 -1177  -955
|         30- 31 |  -989  -831
|  1,1127  0-  9 |     0 -1257  -766  -949  -517 -1479  -700 -1227 -1016 -1790
|         10- 19 |  -842  -652  -902  -986 -1612  -993 -1129 -1706  -495 -1345
|         20- 29 |  -349 -1054 -1236 -1973 -1502  -851  -806  -884 -1337  -970
|         30- 31 | -1060  -566
|  1,1159  0-  9 |     0 -1258 -1170  -566 -1044 -1278  -551 -1155 -1132   155
|         10- 19 |  -619  -525  -580  -538 -1458  -487  -727 -2602 -1042  -626
|         20- 29 | -1077  -518 -1355 -1507 -1292  -478  -655  -581 -1267 -1145
|         30- 31 | -1128 -1032
|  1,1191  0-  9 |     0 -1258 -1571  -730 -1211 -1248 -1318 -1198 -1217  -559
|         10- 19 | -1246 -1320 -1346 -1000 -1369  -963 -1002 -1406 -1210 -1348
|         20- 29 | -1272  -983 -1321 -1356 -1237 -1265 -1431 -1152 -1249 -1229
|         30- 31 | -1206 -1218
|  1,1223  0-  9 |     0 -1255  -988 -1036  -483 -1522 -1033 -1224 -1146 -1334
|         10- 19 | -1025 -1045 -1018 -1033 -1299 -1031 -1279 -1931  -456 -1510
|         20- 29 |  -655 -1029 -1284 -1439 -1449 -1028 -1023 -1027 -1452 -1143
|         30- 31 | -1174  -689
|  1,1255  0-  9 |     0 -1257 -1197 -1183 -1243 -1017 -1215 -1158 -1139 -1451
|         10- 19 | -1094 -1221 -1101 -1222  -792 -1272 -1467  -844 -1245 -1270
|         20- 29 | -1103 -1259 -1165 -1102 -1242 -1158 -1050 -1125  -980 -1042
|         30- 31 | -1064 -1064
|  1,1287  0-  9 |     0 -1259 -1179 -1456 -1513 -1147 -1818 -1250 -1183 -2746
|         10- 19 | -1469 -1991 -1444 -1703  -998 -1913 -1154   -45 -1924 -1741
|         20- 29 | -1314 -1642 -1121  -769 -1295 -2016 -1367 -1537 -1102 -1164
|         30- 31 | -1256 -1359
|  1,1319  0-  9 |     0 -1257 -1000  -945  -507 -1488 -1090 -1189 -1125 -1182
|         10- 19 |  -975 -1182  -961  -957 -1349 -1014 -1249 -1519  -481 -1546
|         20- 29 |  -727 -1003 -1448 -1782 -1449 -1051  -970  -980 -1421 -1131
|         30- 31 | -1190  -717
|  1,1351  0-  9 |     0 -1257 -1097 -1183 -1243 -1017 -1215 -1158 -1032 -1321
|----------------|-------------------------------------------------------------
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|---------------- |-------------------------------------------------------------|
| S., W.  COLUMN  |                     CORRECTION VALUE                        |
|---------------- |-------------------------------------------------------------|
|  1,1831  0-  9  |     0 -1255  -796  -859  -512 -1439  -891 -1179  -990 -1488 |
|         10- 19  |  -799  -890  -813  -901 -1177  -950 -1146 -1436  -488 -1367 |
|         20- 29  |  -527  -950 -1284 -1600 -1470  -888  -766  -835 -1296  -980 |
|         30- 31  | -1077  -565                                                 |
|  1,1863  0-  9  |     0 -1258  -663  -695  -609 -1406  -840 -1206  -992 -2260 |
|         10- 19  |  -696  -884  -732  -785 -1034  -975 -1128  -829  -590 -1290 |
|         20- 29  |  -510  -978 -1215 -1453 -1553  -955  -636  -786 -1261  -946 |
|         30- 31  | -1118  -641                                                 |
|  1,1895  0-  9  |     0 -1257  -990 -1260 -1150 -1134  -834 -1266 -1034 -1100 |
|         10- 19  | -1165 -1035 -1189 -1267 -1288 -1238 -1422 -1256 -1153 -1007 |
|         20- 29  |  -839 -1274 -1161 -1210 -1383 -1084 -1120 -1179 -1093 -1012 |
|         30- 31  | -1077  -980                                                 |
|  1,1927  0-  9  |     0 -1258 -1283  -945 -1102 -1228  -682 -1182 -1047  -730 |
|         10- 19  |  -874  -678  -900  -938 -1252  -866 -1069 -1775 -1102  -880 |
|         20- 29  |  -830  -928 -1185 -1265 -1276  -710  -877  -880 -1178 -1035 |
|         30- 31  | -1083  -937                                                 |
|  1,1959  0-  9  |     0 -1260 -1170 -1850 -1515 -1255 -1867 -1214 -1188 -2806 |
|         10- 19  | -1761 -1843 -1802 -1904  -883 -1924 -2092    23 -1526 -1791 |
|         20- 29  | -1504 -1948 -1119 -1043 -1289 -1883 -1714 -1801 -1213 -1314 |
|         30- 31  | -1279 -1403                                                 |
|---------------- |-------------------------------------------------------------|
|---------|-----------------|-------------------------------------------------|
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|---------|------------------|-------------------------------------------------|
| Word no |     Content      |                     Meaning                     |
|---------|------------------|-------------------------------------------------|
|    1    |              20  | Records    Length of table                      |
|    2    |              93  | Words                                           |
|---------|------------------|-------------------------------------------------|

|     NAME SECTION                                                             |
|    3    |               3  | Length of name section                          |
|    4    |               3  | Table = long kerning                            |
|    5    |               0  | Following part number                           |
|---------|------------------|-------------------------------------------------
|     RECORD INFORMATION                                                       |
|     ------------------                                                       |
|    6    |              19  | Length of record information                    |
|    7    |             195  | Number of columns of correction matrix          |
|    8    |             195  | Number of lines of correction matrix            |
|    9    |               1  | Unit size is 1/100 mm                           |
|   10    |             991  | Base upper case (1st spacing letter)            |
|   11    |             992  | Base lower case (2nd spacing letter)            |
|   12    |            1850  | Left side bearing of 1st spacing letter         |
|   13    |            1850  | Right side bearing of 1st spacing letter        |
|   14    |            1400  | Left side bearing of 2nd spacing letter         |
|   15    |            1400  | Right side bearing of 2nd spacing letter        |
|   16    |           -5000  | Minimum distance on the level of baselines      |
|   17    |           -5000  | Minimum distance between baselines              |
|   18    |               0  | Factor for condensation of white space          |
|   19    |               0  | Distance function appropriate to geom. mean     |
|   20    |               0  | Italic angle (in 1/10 degree)                   |
|   21    |             800  | Serif height         (in 1/100 mm)              |
|   22    |           10000  | Cap height           are given                  |
|   23    |            7000  | x-height             specially for              |
|   24    |           -2600  | Descender length     kerning calculation        |
|---------|------------------|-------------------------------------------------
|     SPACING INDEX                                                            |
|     -------------                                                            |
|   25    |               1  | Records    Length of spacing index              |
|   26    |             954  | Words                                           |
|         |                  |                                                 |
|  227    |    0        198  | Record/wordp. f. pairs  101,*   (abs.   1,1176) |
|  229    |    0        393  | Record/wordp. f. pairs  102,*   (abs.   1,1371) |
|  231    |    0        588  | Record/wordp. f. pairs  103,*   (abs.   1,1566) |
|  233    |    0        783  | Record/wordp. f. pairs  104,*   (abs.   1,1761) |
|  235    |    0        978  | Record/wordp. f. pairs  105,*   (abs.   1,1956) |
|  237    |    0       1173  | Record/wordp. f. pairs  106,*   (abs.   2, 103) |
|  239    |    0       1368  | Record/wordp. f. pairs  107,*   (abs.   2, 298) |
|  241    |    0       1563  | Record/wordp. f. pairs  108,*   (abs.   2, 493) |
|  243    |    0       1758  | Record/wordp. f. pairs  109,*   (abs.   2, 688) |
|  245    |    0       1953  | Record/wordp. f. pairs  110,*   (abs.   2, 883) |
|  247    |    1        100  | Record/wordp. f. pairs  111,*   (abs.   2,1078) |
|  249    |    1        295  | Record/wordp. f. pairs  112,*   (abs.   2,1273) |
|  251    |    1        490  | Record/wordp. f. pairs  113,*   (abs.   2,1468) |
|  253    |    1        685  | Record/wordp. f. pairs  114,*   (abs.   2,1663) |
|  255    |    1        880  | Record/wordp. f. pairs  115,*   (abs.   2,1858) |
|  257    |    1       1075  | Record/wordp. f. pairs  116,*   (abs.   3,    5) |
|  259    |    1       1270  | Record/wordp. f. pairs  117,*   (abs.   3, 200) |
|  261    |    1       1465  | Record/wordp. f. pairs  118,*   (abs.   3, 395) |
|  263    |    1       1660  | Record/wordp. f. pairs  119,*   (abs.   3, 590) |
|  265    |    1       1855  | Record/wordp. f. pairs  120,*   (abs.   3, 785) |
|  267    |    2          2  | Record/wordp. f. pairs  121,*   (abs.   3, 980) |
|  269    |    2        197  | Record/wordp. f. pairs  122,*   (abs.   3,1175) |
|---------|------------------|-------------------------------------------------|
```

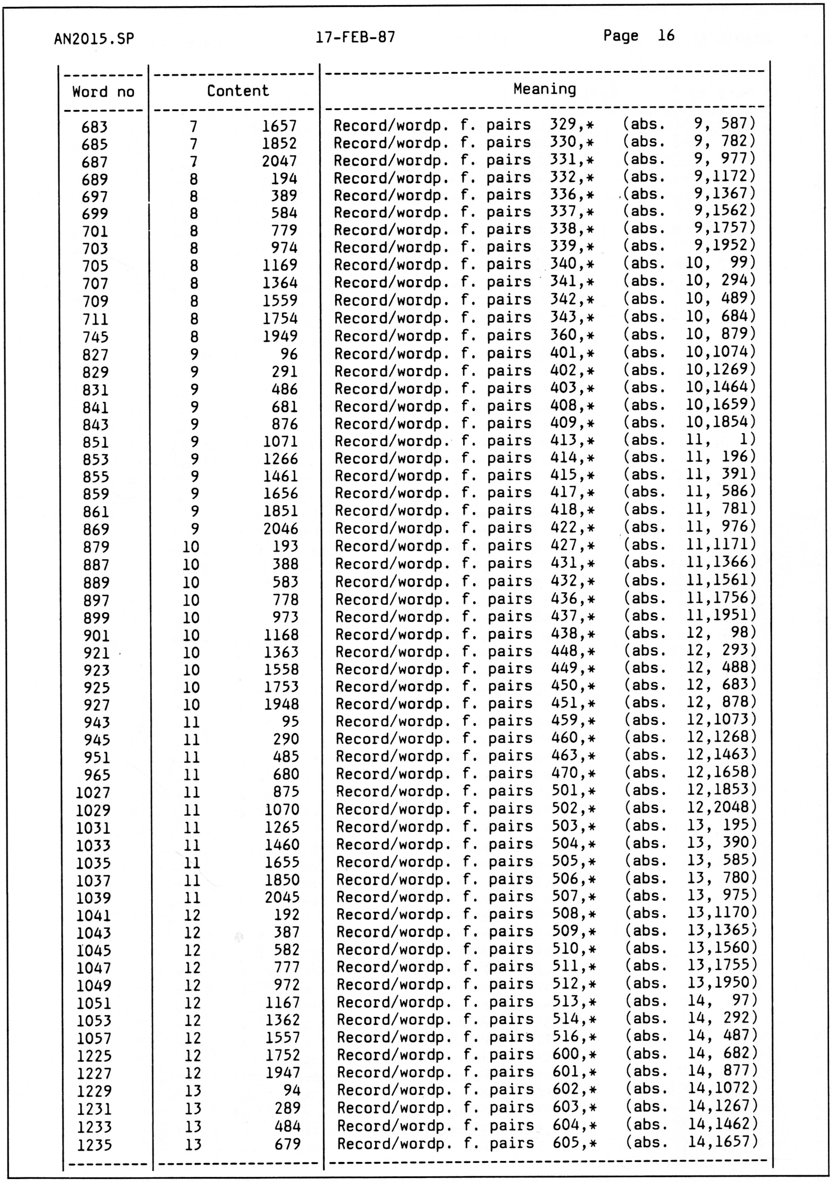

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  Word no        Content                            Meaning
 ---------  ------------------  ------------------------------------------------
    683        7        1657      Record/wordp. f. pairs  329,*   (abs.   9, 587)
    685        7        1852      Record/wordp. f. pairs  330,*   (abs.   9, 782)
    687        7        2047      Record/wordp. f. pairs  331,*   (abs.   9, 977)
    689        8         194      Record/wordp. f. pairs  332,*   (abs.   9,1172)
    697        8         389      Record/wordp. f. pairs  336,*   (abs.   9,1367)
    699        8         584      Record/wordp. f. pairs  337,*   (abs.   9,1562)
    701        8         779      Record/wordp. f. pairs  338,*   (abs.   9,1757)
    703        8         974      Record/wordp. f. pairs  339,*   (abs.   9,1952)
    705        8        1169      Record/wordp. f. pairs  340,*   (abs.  10,  99)
    707        8        1364      Record/wordp. f. pairs  341,*   (abs.  10, 294)
    709        8        1559      Record/wordp. f. pairs  342,*   (abs.  10, 489)
    711        8        1754      Record/wordp. f. pairs  343,*   (abs.  10, 684)
    745        8        1949      Record/wordp. f. pairs  360,*   (abs.  10, 879)
    827        9          96      Record/wordp. f. pairs  401,*   (abs.  10,1074)
    829        9         291      Record/wordp. f. pairs  402,*   (abs.  10,1269)
    831        9         486      Record/wordp. f. pairs  403,*   (abs.  10,1464)
    841        9         681      Record/wordp. f. pairs  408,*   (abs.  10,1659)
    843        9         876      Record/wordp. f. pairs  409,*   (abs.  10,1854)
    851        9        1071      Record/wordp. f. pairs  413,*   (abs.  11,   1)
    853        9        1266      Record/wordp. f. pairs  414,*   (abs.  11, 196)
    855        9        1461      Record/wordp. f. pairs  415,*   (abs.  11, 391)
    859        9        1656      Record/wordp. f. pairs  417,*   (abs.  11, 586)
    861        9        1851      Record/wordp. f. pairs  418,*   (abs.  11, 781)
    869        9        2046      Record/wordp. f. pairs  422,*   (abs.  11, 976)
    879       10         193      Record/wordp. f. pairs  427,*   (abs.  11,1171)
    887       10         388      Record/wordp. f. pairs  431,*   (abs.  11,1366)
    889       10         583      Record/wordp. f. pairs  432,*   (abs.  11,1561)
    897       10         778      Record/wordp. f. pairs  436,*   (abs.  11,1756)
    899       10         973      Record/wordp. f. pairs  437,*   (abs.  11,1951)
    901       10        1168      Record/wordp. f. pairs  438,*   (abs.  12,  98)
    921       10        1363      Record/wordp. f. pairs  448,*   (abs.  12, 293)
    923       10        1558      Record/wordp. f. pairs  449,*   (abs.  12, 488)
    925       10        1753      Record/wordp. f. pairs  450,*   (abs.  12, 683)
    927       10        1948      Record/wordp. f. pairs  451,*   (abs.  12, 878)
    943       11          95      Record/wordp. f. pairs  459,*   (abs.  12,1073)
    945       11         290      Record/wordp. f. pairs  460,*   (abs.  12,1268)
    951       11         485      Record/wordp. f. pairs  463,*   (abs.  12,1463)
    965       11         680      Record/wordp. f. pairs  470,*   (abs.  12,1658)
   1027       11         875      Record/wordp. f. pairs  501,*   (abs.  12,1853)
   1029       11        1070      Record/wordp. f. pairs  502,*   (abs.  12,2048)
   1031       11        1265      Record/wordp. f. pairs  503,*   (abs.  13, 195)
   1033       11        1460      Record/wordp. f. pairs  504,*   (abs.  13, 390)
   1035       11        1655      Record/wordp. f. pairs  505,*   (abs.  13, 585)
   1037       11        1850      Record/wordp. f. pairs  506,*   (abs.  13, 780)
   1039       11        2045      Record/wordp. f. pairs  507,*   (abs.  13, 975)
   1041       12         192      Record/wordp. f. pairs  508,*   (abs.  13,1170)
   1043       12         387      Record/wordp. f. pairs  509,*   (abs.  13,1365)
   1045       12         582      Record/wordp. f. pairs  510,*   (abs.  13,1560)
   1047       12         777      Record/wordp. f. pairs  511,*   (abs.  13,1755)
   1049       12         972      Record/wordp. f. pairs  512,*   (abs.  13,1950)
   1051       12        1167      Record/wordp. f. pairs  513,*   (abs.  14,  97)
   1053       12        1362      Record/wordp. f. pairs  514,*   (abs.  14, 292)
   1057       12        1557      Record/wordp. f. pairs  516,*   (abs.  14, 487)
   1225       12        1752      Record/wordp. f. pairs  600,*   (abs.  14, 682)
   1227       12        1947      Record/wordp. f. pairs  601,*   (abs.  14, 877)
   1229       13          94      Record/wordp. f. pairs  602,*   (abs.  14,1072)
   1231       13         289      Record/wordp. f. pairs  603,*   (abs.  14,1267)
   1233       13         484      Record/wordp. f. pairs  604,*   (abs.  14,1462)
   1235       13         679      Record/wordp. f. pairs  605,*   (abs.  14,1657)
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  Word no         Content                          Meaning
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   1237        13        874     Record/wordp. f. pairs  606,*   (abs.  14,1852)
   1239        13       1069     Record/wordp. f. pairs  607,*   (abs.  14,2047)
   1241        13       1264     Record/wordp. f. pairs  608,*   (abs.  15, 194)
   1243        13       1459     Record/wordp. f. pairs  609,*   (abs.  15, 389)
   1245        13       1654     Record/wordp. f. pairs  610,*   (abs.  15, 584)
   1247        13       1849     Record/wordp. f. pairs  611,*   (abs.  15, 779)
   1249        13       2044     Record/wordp. f. pairs  612,*   (abs.  15, 974)
   1251        14        191     Record/wordp. f. pairs  613,*   (abs.  15,1169)
   1253        14        386     Record/wordp. f. pairs  614,*   (abs.  15,1364)
   1255        14        581     Record/wordp. f. pairs  615,*   (abs.  15,1559)
   1257        14        776     Record/wordp. f. pairs  616,*   (abs.  15,1754)
   1259        14        971     Record/wordp. f. pairs  617,*   (abs.  15,1949)
   1261        14       1166     Record/wordp. f. pairs  618,*   (abs.  16,  96)
   1263        14       1361     Record/wordp. f. pairs  619,*   (abs.  16, 291)
   1265        14       1556     Record/wordp. f. pairs  620,*   (abs.  16, 486)
   1267        14       1751     Record/wordp. f. pairs  621,*   (abs.  16, 681)
   1269        14       1946     Record/wordp. f. pairs  622,*   (abs.  16, 876)
   1271        15         93     Record/wordp. f. pairs  623,*   (abs.  16,1071)
   1273        15        288     Record/wordp. f. pairs  624,*   (abs.  16,1266)
   1275        15        483     Record/wordp. f. pairs  625,*   (abs.  16,1461)
   1277        15        678     Record/wordp. f. pairs  626,*   (abs.  16,1656)
   1279        15        873     Record/wordp. f. pairs  627,*   (abs.  16,1851)
   1281        15       1068     Record/wordp. f. pairs  628,*   (abs.  16,2046)
   1283        15       1263     Record/wordp. f. pairs  629,*   (abs.  17, 193)
   1285        15       1458     Record/wordp. f. pairs  630,*   (abs.  17, 388)
   1287        15       1653     Record/wordp. f. pairs  631,*   (abs.  17, 583)
   1289        15       1848     Record/wordp. f. pairs  632,*   (abs.  17, 778)
   1291        15       2043     Record/wordp. f. pairs  633,*   (abs.  17, 973)
   1293        16        190     Record/wordp. f. pairs  634,*   (abs.  17,1168)
   1295        16        385     Record/wordp. f. pairs  635,*   (abs.  17,1363)
   1297        16        580     Record/wordp. f. pairs  636,*   (abs.  17,1558)
   1299        16        775     Record/wordp. f. pairs  637,*   (abs.  17,1753)
   1301        16        970     Record/wordp. f. pairs  638,*   (abs.  17,1948)
   1303        16       1165     Record/wordp. f. pairs  639,*   (abs.  18,  95)
   1305        16       1360     Record/wordp. f. pairs  640,*   (abs.  18, 290)
   1309        16       1555     Record/wordp. f. pairs  642,*   (abs.  18, 485)
   1311        16       1750     Record/wordp. f. pairs  643,*   (abs.  18, 680)
   1313        16       1945     Record/wordp. f. pairs  644,*   (abs.  18, 875)
   1317        17         92     Record/wordp. f. pairs  646,*   (abs.  18,1070)
   1321        17        287     Record/wordp. f. pairs  648,*   (abs.  18,1265)
   1323        17        482     Record/wordp. f. pairs  649,*   (abs.  18,1460)
   1329        17        677     Record/wordp. f. pairs  652,*   (abs.  18,1655)
   1331        17        872     Record/wordp. f. pairs  653,*   (abs.  18,1850)
   1333        17       1067     Record/wordp. f. pairs  654,*   (abs.  18,2045)
   1335        17       1262     Record/wordp. f. pairs  655,*   (abs.  19, 192)
   1337        17       1457     Record/wordp. f. pairs  656,*   (abs.  19, 387)
   1381        17       1652     Record/wordp. f. pairs  678,*   (abs.  19, 582)
   1383        17       1847     Record/wordp. f. pairs  679,*   (abs.  19, 777)
   1421        17       2042     Record/wordp. f. pairs  698,*   (abs.  19, 972)
   1423        18        189     Record/wordp. f. pairs  699,*   (abs.  19,1167)
   2005        18        384     Record/wordp. f. pairs  990,*   (abs.  19,1362)
   2007        18        579     Record/wordp. f. pairs  991,*   (abs.  19,1557)
   2009        18        774     Record/wordp. f. pairs  992,*   (abs.  19,1752)
   2023        18        969     Record/wordp. f. pairs  999,*   (abs.  19,1947)
   2127                    1     Word pointer for character pairs  *, 101
   2128                    2     Word pointer for character pairs  *, 102
   2129                    3     Word pointer for character pairs  *, 103
   2130                    4     Word pointer for character pairs  *, 104
   2131                    5     Word pointer for character pairs  *, 105
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| --------- | ------------------ | ---------------------------------------------- |
|  Word no  |      Content       |                   Meaning                      |
| --------- | ------------------ | ---------------------------------------------- |
|  2679     |              183   |  Word pointer for character pairs  *, 653      |
|  2680     |              184   |  Word pointer for character pairs  *, 654      |
|  2681     |              185   |  Word pointer for character pairs  *, 655      |
|  2682     |              186   |  Word pointer for character pairs  *, 656      |
|  2704     |              187   |  Word pointer for character pairs  *, 678      |
|  2705     |              188   |  Word pointer for character pairs  *, 679      |
|  2724     |              189   |  Word pointer for character pairs  *, 698      |
|  2725     |              190   |  Word pointer for character pairs  *, 699      |
|  3016     |              191   |  Word pointer for character pairs  *, 990      |
|  3017     |              192   |  Word pointer for character pairs  *, 991      |
|  3018     |              193   |  Word pointer for character pairs  *, 992      |
|  3025     |              194   |  Word pointer for character pairs  *, 999      |
| --------- | ------------------ | ---------------------------------------------- |
|      Spacing information                                                        |
|      -------------------                                                        |
|  3027     |               18   |  Records     Length of table                   |
|  3028     |             1163   |  Words                                         |
|           |                    |                                                |
| ---------------- | ------------------------------------------------------------ |
|  S., W.  COLUMN  |                   CORRECTION VALUES                          |
| ---------------- | ------------------------------------------------------------ |
|   1, 981  0-  9  |     0     0     0     0     0     0     0     0     0     0  |
|          10- 19  |     0     0     0     0     0     0     0     0     0     0  |
|    for   20- 29  |     0     0     0     0     0     0     0     0     0     0  |
|    1,*   30- 39  |     0     0     0     0     0     0     0     0     0     0  |
|          40- 49  |     0     0     0     0     0     0     0     0     0     0  |
|          50- 59  |     0     0     0     0     0     0     0     0     0     0  |
|          60- 69  |     0     0     0     0     0     0     0     0     0     0  |
|          70- 79  |     0     0     0     0     0     0     0     0     0     0  |
|          80- 89  |     0     0     0     0     0     0     0     0     0     0  |
|          90- 99  |     0     0     0     0     0     0     0     0     0     0  |
|         100-109  |     0     0     0     0     0     0     0     0     0     0  |
|         110-119  |     0     0     0     0     0     0     0     0     0     0  |
|         120-129  |     0     0     0     0     0     0     0     0     0     0  |
|         130-139  |     0     0     0     0     0     0     0     0     0     0  |
|         140-149  |     0     0     0     0     0     0     0     0     0     0  |
|         150-159  |     0     0     0     0     0     0     0     0     0     0  |
|         160-169  |     0     0     0     0     0     0     0     0     0     0  |
|         170-179  |     0     0     0     0     0     0     0     0     0     0  |
|         180-189  |     0     0     0     0     0     0     0     0     0     0  |
|         190-194  |     0     0     0     0     0                              |
|  1,1176   0-  9  |     0  -712  -164  -417  -164  -164  -164  -389  -164  -164  |
|          10- 19  |  -311  -164  -163  -161   -97  -383  -164  -377  -164     2  |
|    for   20- 29  |  -442  -627 -1523 -1224   -58 -1461   208  -322  -414  -383  |
|  101,*   30- 39  |     0  -736     0     0     0     0     0 -1111     0  -417  |
|          40- 49  |     0     0     0     0     0     0     0     0     0  -383  |
|          50- 59  |     0  -627     0     0   346  -203  -106  -113  -101   294  |
|          60- 69  |    42   -60   653   936    40    39   317   317   -92   172  |
|          70- 79  |  -103   317   242   -39    19  -420  -274   264     3   497  |
|          80- 89  |   368  -117   -38   617   317     0     0   144   144   144  |
|          90- 99  |   144   144   144     0     0   346     0     0   346     0  |
|         100-109  |  -106     0     0     0     0     0     0     0     0   -95  |
|         110-119  |     0     0     0   169     0     0     0     0     0     0  |
|         120-129  |  -728   -16  -361  -216   163    27  -500  -273     6    26  |
|         130-139  |  1302  1401  1136     0     0     0  2007  1608  2146   245  |
|         140-149  |  1173  3007  1684  1535  -758  -411  -658  -311  2284   556  |
|         150-159  |  2268   853  1476   841   631   607   133   182  1083  1583  |
|         160-169  |  1542   890   148  1265   224   643  1375   972   972  -596  |
|         170-179  |     0     0     0     0     0     0     0     0     0     0  |
| ---------------- | ------------------------------------------------------------ |
---------------   ---------------------------------------------------------------------
S., W.  COLUMN                          CORRECTION VALUES
---------------   ---------------------------------------------------------------------
        180-189        0      0      0   2684   2684      0      0      0      0    999
        190-194      961   1565   -285    279      0
1,1371   0-  9         0   -272    373    354    373    373    373    383    373    373
        10- 19       344    373    374    372    437    390    373    398    373    635
 for    20- 29       790    142   -206     46    481   -205    747    104    358    375
102,*   30- 39         0   -296      0      0      0      0      0   -671      0    354
        40- 49         0      0      0      0      0      0      0      0      0    390
        50- 59         0    142      0      0    594     29    254    248    259    494
        60- 69       174     58    602    985    158    156    349    349    266    433
        70- 79       257    349    250    277    329     69    197    171    336    436
        80- 89       608    242    294    571    449      0      0    344    344    344
        90- 99       344    344    344      0      0    594      0      0    594      0
        100-109      254      0      0      0      0      0      0      0      0    263
        110-119        0      0      0    498      0      0      0      0      0      0
        120-129      -18    555    301    591    818    782    246    498    684    781
        130-139     1897   2076   1397      0      0      0   1320   1599   2828    867
        140-149      495   2320    991   1547   1185   1556   1285   1656   1591   1191
        150-159     2619   1590   1687    843    883    607    386    756   1769   2269
        160-169     2218   1642    818   1882    842   1429   1974   1822   1822   1231
        170-179        0      0      0      0      0      0      0      0      0      0
        180-189        0      0      0   1991   1991      0      0      0      0   1639
        190-194     1601   2182    332    345      0
1,1566   0-  9         0   -271    476    295    476    476    476    318    476    476
        10- 19       413    476    477    477    543    334    476    336    488    571
 for    20- 29      1163    203    -46    187    632    -15    845    108    307    333
103,*   30- 39         0   -295      0      0      0      0      0   -670      0    295
        40- 49         0      0      0      0      0      0      0      0      0    334
        50- 59         0    203      0      0    404   -137     41     32     44    472
        60- 69        27    -88    576    888     12     11    296    296     53    364
        70- 79        41    296     87    225    238     37    160    111    322    332
        80- 89       432     27     93    505    396      0      0    322    322    322
        90- 99       322    322    322      0      0    404      0      0    404      0
        100-109       41      0      0      0      0      0      0      0      0     51
        110-119        0      0      0    435      0      0      0      0      0      0
        120-129      173    628    344    397    880    704    429    441    805    748
        130-139     1905   2140   1081      0      0      0   1182   1526   2570     47
        140-149      368   2182    839   1478   1659   2028   1759   2128   1439   1323
        150-159     2610   1744   1644    773    595    554     97    786    932   1432
        160-169     1337   1580    888   1951    898   1350   1973   1928   1928   1718
        170-179        0      0      0      0      0      0      0      0      0      0
        180-189        0      0      0   1839   1839      0      0      0      0   1724
        190-194     1686   2251    401    162      0
1,1761   0-  9         0   -544    155    458    155    155    155    480    155    155
        10- 19       114    155    156    149    214    492    155    497    155    340
 for    20- 29       501    -45   -397   -141   -100   -414    222   -176    454    479
104,*   30- 39         0   -567      0      0      0      0      0   -942      0    458
        40- 49         0      0      0      0      0      0      0      0      0    492
        50- 59         0    -45      0      0    264    -86    133    123    134    524
        60- 69        48    -77    609    828     23     21    262    262    138    368
        70- 79       124    262      4    329    279    107    222     44    300    382
        80- 89       298    114    161    518    362      0      0    374    374    374
        90- 99       374    374    374      0      0    264      0      0    264      0
        100-109      133      0      0      0      0      0      0      0      0    140
        110-119        0      0      0    546      0      0      0      0      0      0
        120-129     -216    286     21    321    618    719     60    229    558    748
        130-139     1629   1854   1271      0      0      0    518   1566   3467    741
        140-149     -308   1518    190   1508   1153   1490   1253   1590    790    973
        150-159     2503   1368   1433    773    749    530    248    494   1907   2407
        160-169     2406   1707    593   1751    616   1119   1919   1799   1799   1234
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|----------------| ------------------------------------------------------------|
| S., W.  COLUMN |                       CORRECTION VALUES                     |
 ----------------  ------------------------------------------------------------
|        130-139 |  2069  1793  1092     0     0     0   504   960  2297  -154 |
|        140-149 |  -326  1504   184   897   530   767   630   867   784   799 |
|        150-159 |  2230  1010  1608   161   106   -52  -391   608   892  1392 |
|        160-169 |  1382  1085    52  1100   267  1194  1463  1099  1099   398 |
|        170-179 |     0     0     0     0     0     0     0     0     0     0 |
|        180-189 |     0     0     0  1184  1184     0     0     0     0  1307 |
|        190-194 |  1269  1400   -31  1400     0                               |
| 19,1947  0-  9 |     0     0     0     0     0     0     0     0     0     0 |
|         10- 19 |     0     0     0     0     0     0     0     0     0     0 |
|   for   20- 29 |     0     0     0     0     0     0     0     0     0     0 |
|   -1,*  30- 39 |     0     0     0     0     0     0     0     0     0     0 |
|         40- 49 |     0     0     0     0     0     0     0     0     0     0 |
|         50- 59 |     0     0     0     0     0     0     0     0     0     0 |
|         60- 69 |     0     0     0     0     0     0     0     0     0     0 |
|         70- 79 |     0     0     0     0     0     0     0     0     0     0 |
|         80- 89 |     0     0     0     0     0     0     0     0     0     0 |
|         90- 99 |     0     0     0     0     0     0     0     0     0     0 |
|        100-109 |     0     0     0     0     0     0     0     0     0     0 |
|        110-119 |     0     0     0     0     0     0     0     0     0     0 |
|        120-129 |     0     0     0     0     0     0     0     0     0     0 |
|        130-139 |     0     0     0     0     0     0     0     0     0     0 |
|        140-149 |     0     0     0     0     0     0     0     0     0     0 |
|        150-159 |     0     0     0     0     0     0     0     0     0     0 |
|        160-169 |     0     0     0     0     0     0     0     0     0     0 |
|        170-179 |     0     0     0     0     0     0     0     0     0     0 |
|        180-189 |     0     0     0     0     0     0     0     0     0     0 |
|        190-194 |     0     0     0     0     0                               |
|----------------| ------------------------------------------------------------|
|---------|------------------|------------------------------------------------|
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  Word no        Content                             Meaning
 ---------  ------------------  ---------------------------------------------------
      1                    1     Records     Length of table
      2                 1357     Words
 ---------  ------------------  ---------------------------------------------------

       NAME SECTION
      3                    3     Length of name section
      4                    6     Table = left/right side bearings and widths
      5                    0     Following part number
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       RECORD INFORMATION
       ------------------
      6                    3     Length of record information
      7                  131     Number of LSB, RSB and widths
      8                    1     Unit size is 1/100 mm
 ---------  ------------------  ---------------------------------------------------
       SPACING INDEX
       -------------
      9                    1     Records     Length of spacing index
     10                  954     Words

    211          0         6     R/wp. for lsb/rsb/width of  101 (abs.    1, 968)
    213          0         9     R/wp. for lsb/rsb/width of  102 (abs.    1, 971)
    215          0        12     R/wp. for lsb/rsb/width of  103 (abs.    1, 974)
    217          0        15     R/wp. for lsb/rsb/width of  104 (abs.    1, 977)
    219          0        18     R/wp. for lsb/rsb/width of  105 (abs.    1, 980)
    221          0        21     R/wp. for lsb/rsb/width of  106 (abs.    1, 983)
    223          0        24     R/wp. for lsb/rsb/width of  107 (abs.    1, 986)
    225          0        27     R/wp. for lsb/rsb/width of  108 (abs.    1, 989)
    227          0        30     R/wp. for lsb/rsb/width of  109 (abs.    1, 992)
    229          0        33     R/wp. for lsb/rsb/width of  110 (abs.    1, 995)
    231          0        36     R/wp. for lsb/rsb/width of  111 (abs.    1, 998)
    233          0        39     R/wp. for lsb/rsb/width of  112 (abs.    1,1001)
    235          0        42     R/wp. for lsb/rsb/width of  113 (abs.    1,1004)
    237          0        45     R/wp. for lsb/rsb/width of  114 (abs.    1,1007)
    239          0        48     R/wp. for lsb/rsb/width of  115 (abs.    1,1010)
    241          0        51     R/wp. for lsb/rsb/width of  116 (abs.    1,1013)
    243          0        54     R/wp. for lsb/rsb/width of  117 (abs.    1,1016)
    245          0        57     R/wp. for lsb/rsb/width of  118 (abs.    1,1019)
    247          0        60     R/wp. for lsb/rsb/width of  119 (abs.    1,1022)
    249          0        63     R/wp. for lsb/rsb/width of  120 (abs.    1,1025)
    251          0        66     R/wp. for lsb/rsb/width of  121 (abs.    1,1028)
    253          0        69     R/wp. for lsb/rsb/width of  122 (abs.    1,1031)
    255          0        72     R/wp. for lsb/rsb/width of  123 (abs.    1,1034)
    257          0        75     R/wp. for lsb/rsb/width of  124 (abs.    1,1037)
    259          0        78     R/wp. for lsb/rsb/width of  125 (abs.    1,1040)
    261          0        81     R/wp. for lsb/rsb/width of  126 (abs.    1,1043)
    263          0        84     R/wp. for lsb/rsb/width of  127 (abs.    1,1046)
    265          0        87     R/wp. for lsb/rsb/width of  128 (abs.    1,1049)
    267          0        90     R/wp. for lsb/rsb/width of  129 (abs.    1,1052)
    411          0        93     R/wp. for lsb/rsb/width of  201 (abs.    1,1055)
    425          0        96     R/wp. for lsb/rsb/width of  208 (abs.    1,1058)
    429          0        99     R/wp. for lsb/rsb/width of  210 (abs.    1,1061)
    483          0       102     R/wp. for lsb/rsb/width of  237 (abs.    1,1064)
    511          0       105     R/wp. for lsb/rsb/width of  251 (abs.    1,1067)
    611          0       108     R/wp. for lsb/rsb/width of  301 (abs.    1,1070)
    613          0       111     R/wp. for lsb/rsb/width of  302 (abs.    1,1073)
    615          0       114     R/wp. for lsb/rsb/width of  303 (abs.    1,1076)
    617          0       117     R/wp. for lsb/rsb/width of  304 (abs.    1,1079)
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|---------|------------------|----------------------------------------------|
| Word no |     Content      |                   Meaning                    |
|---------|------------------|----------------------------------------------|
| 1227    |   0         297  | R/wp. for lsb/rsb/width of  609 (abs.   1,1259)
| 1229    |   0         300  | R/wp. for lsb/rsb/width of  610 (abs.   1,1262)
| 1231    |   0         303  | R/wp. for lsb/rsb/width of  611 (abs.   1,1265)
| 1233    |   0         306  | R/wp. for lsb/rsb/width of  612 (abs.   1,1268)
| 1235    |   0         309  | R/wp. for lsb/rsb/width of  613 (abs.   1,1271)
| 1237    |   0         312  | R/wp. for lsb/rsb/width of  614 (abs.   1,1274)
| 1239    |   0         315  | R/wp. for lsb/rsb/width of  615 (abs.   1,1277)
| 1241    |   0         318  | R/wp. for lsb/rsb/width of  616 (abs.   1,1280)
| 1243    |   0         321  | R/wp. for lsb/rsb/width of  617 (abs.   1,1283)
| 1245    |   0         324  | R/wp. for lsb/rsb/width of  618 (abs.   1,1286)
| 1247    |   0         327  | R/wp. for lsb/rsb/width of  619 (abs.   1,1289)
| 1249    |   0         330  | R/wp. for lsb/rsb/width of  620 (abs.   1,1292)
| 1251    |   0         333  | R/wp. for lsb/rsb/width of  621 (abs.   1,1295)
| 1253    |   0         336  | R/wp. for lsb/rsb/width of  622 (abs.   1,1298)
| 1255    |   0         339  | R/wp. for lsb/rsb/width of  623 (abs.   1,1301)
| 1257    |   0         342  | R/wp. for lsb/rsb/width of  624 (abs.   1,1304)
| 1259    |   0         345  | R/wp. for lsb/rsb/width of  625 (abs.   1,1307)
| 1261    |   0         348  | R/wp. for lsb/rsb/width of  626 (abs.   1,1310)
| 1263    |   0         351  | R/wp. for lsb/rsb/width of  627 (abs.   1,1313)
| 1265    |   0         354  | R/wp. for lsb/rsb/width of  628 (abs.   1,1316)
| 1267    |   0         357  | R/wp. for lsb/rsb/width of  629 (abs.   1,1319)
| 1269    |   0         360  | R/wp. for lsb/rsb/width of  630 (abs.   1,1322)
| 1271    |   0         363  | R/wp. for lsb/rsb/width of  631 (abs.   1,1325)
| 1273    |   0         366  | R/wp. for lsb/rsb/width of  632 (abs.   1,1328)
| 1275    |   0         369  | R/wp. for lsb/rsb/width of  633 (abs.   1,1331)
| 1277    |   0         372  | R/wp. for lsb/rsb/width of  634 (abs.   1,1334)
| 1315    |   0         375  | R/wp. for lsb/rsb/width of  653 (abs.   1,1337)
| 1317    |   0         378  | R/wp. for lsb/rsb/width of  654 (abs.   1,1340)
| 1405    |   0         381  | R/wp. for lsb/rsb/width of  698 (abs.   1,1343)
| 1407    |   0         384  | R/wp. for lsb/rsb/width of  699 (abs.   1,1346)
| 1989    |   0         387  | R/wp. for lsb/rsb/width of  990 (abs.   1,1349)
| 1991    |   0         390  | R/wp. for lsb/rsb/width of  991 (abs.   1,1352)
| 1993    |   0         393  | R/wp. for lsb/rsb/width of  992 (abs.   1,1355)
|---------|------------------|----------------------------------------------|
      Spacing information
      -------------------
 3011    |                 0 | Records     Length of table
 3012    |               395 | Words
         |                   |
|---------|------------------|----------------------------------------------|
| S., W.  |     Content      |                   Meaning                    |
|---------|------------------|----------------------------------------------|
|  1  965 |    0     0 15000 | LSB, RSB and width of character    1
|  1  968 |   96   236 11523 | LSB, RSB and width of character  101
|  1  971 | 1258  1473 11833 | LSB, RSB and width of character  102
|  1  974 | 1321  1526 12424 | LSB, RSB and width of character  103
|  1  977 | 1258  1355 13344 | LSB, RSB and width of character  104
|  1  980 | 1258  1611 11698 | LSB, RSB and width of character  105
|  1  983 | 1258  1002 10641 | LSB, RSB and width of character  106
|  1  986 | 1345   861 13511 | LSB, RSB and width of character  107
|  1  989 | 1258  1258 13770 | LSB, RSB and width of character  108
|  1  992 | 1258  1258  7108 | LSB, RSB and width of character  109
|  1  995 |  259  1023  6824 | LSB, RSB and width of character  110
|  1  998 | 1258   695 12431 | LSB, RSB and width of character  111
|  1 1001 | 1259   742 10445 | LSB, RSB and width of character  112
|  1 1004 | 1163  1224 16087 | LSB, RSB and width of character  113
|  1 1007 | 1179   928 13402 | LSB, RSB and width of character  114
|  1 1010 | 1356  1354 13676 | LSB, RSB and width of character  115
|  1 1013 | 1258  1036 10848 | LSB, RSB and width of character  116
|---------|------------------|----------------------------------------------|
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S., W.	Content	Meaning
1 1193	653 765 10821	LSB, RSB and width of character 449
1 1196	1408 858 7843	LSB, RSB and width of character 501
1 1199	1383 1471 9198	LSB, RSB and width of character 502
1 1202	1382 1569 8703	LSB, RSB and width of character 503
1 1205	884 1113 8502	LSB, RSB and width of character 504
1 1208	1792 1523 9051	LSB, RSB and width of character 505
1 1211	1637 1685 9330	LSB, RSB and width of character 506
1 1214	1583 712 8304	LSB, RSB and width of character 507
1 1217	1629 1610 9231	LSB, RSB and width of character 508
1 1220	1672 1640 9319	LSB, RSB and width of character 509
1 1223	1659 1658 9382	LSB, RSB and width of character 510
1 1226	2186 2352 13814	LSB, RSB and width of character 511
1 1229	2884 2748 11906	LSB, RSB and width of character 512
1 1232	2389 2454 10964	LSB, RSB and width of character 513
1 1235	2417 2417 6734	LSB, RSB and width of character 601
1 1238	2951 2951 7802	LSB, RSB and width of character 602
1 1241	3030 3030 8245	LSB, RSB and width of character 603
1 1244	3036 3036 8162	LSB, RSB and width of character 604
1 1247	3416 3416 8542	LSB, RSB and width of character 605
1 1250	3417 3417 15734	LSB, RSB and width of character 606
1 1253	2394 2456 7042	LSB, RSB and width of character 607
1 1256	2910 2845 7947	LSB, RSB and width of character 608
1 1259	2356 2261 6809	LSB, RSB and width of character 609
1 1262	2259 2353 6804	LSB, RSB and width of character 610
1 1265	2356 2261 9609	LSB, RSB and width of character 611
1 1268	2259 2353 9604	LSB, RSB and width of character 612
1 1271	2394 2456 9842	LSB, RSB and width of character 613
1 1274	3002 3017 8005	LSB, RSB and width of character 614
1 1277	2835 2819 7640	LSB, RSB and width of character 615
1 1280	2561 2137 9480	LSB, RSB and width of character 616
1 1283	1905 2366 9053	LSB, RSB and width of character 617
1 1286	1910 1434 7640	LSB, RSB and width of character 618
1 1289	1434 1910 7640	LSB, RSB and width of character 619
1 1292	1684 1434 5628	LSB, RSB and width of character 620
1 1295	1435 1682 5627	LSB, RSB and width of character 621
1 1298	1601 1615 8311	LSB, RSB and width of character 622
1 1301	2129 2129 8032	LSB, RSB and width of character 623
1 1304	2129 2129 10235	LSB, RSB and width of character 624
1 1307	2117 2117 12191	LSB, RSB and width of character 625
1 1310	2504 1465 7545	LSB, RSB and width of character 626
1 1313	1423 2503 7502	LSB, RSB and width of character 627
1 1316	3179 1633 7812	LSB, RSB and width of character 628
1 1319	1632 3176 7809	LSB, RSB and width of character 629
1 1322	2061 2487 15180	LSB, RSB and width of character 630
1 1325	2879 2990 11432	LSB, RSB and width of character 631
1 1328	2236 2243 10575	LSB, RSB and width of character 632
1 1331	2236 2243 10575	LSB, RSB and width of character 633
1 1334	2168 2168 8710	LSB, RSB and width of character 634
1 1337	3394 3456 9042	LSB, RSB and width of character 653
1 1340	3394 3456 9042	LSB, RSB and width of character 654
1 1343	1893 1856 12202	LSB, RSB and width of character 698
1 1346	1893 2121 19014	LSB, RSB and width of character 699
1 1349	2479 2479 19958	LSB, RSB and width of character 990
1 1352	629 629 16258	LSB, RSB and width of character 991
1 1355	521 521 16042	LSB, RSB and width of character 992

Appendix U
Touching tables

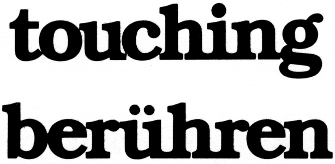
Touching tables do not differ in structure from the kerning tables (see appendix T).

Touching tables are of importance to typesetting for two reasons. In the first place one can find correction values for the actual touching, and also gain additional information to help with the kerning of large cap heights – e.g. in window display text.

We assume in outside-advertising text that the kerning works to a good effect provided that the typesetting is carried out with cap heights of up to 10 cm. One has to mention, however, that such text lines are generally seen from a distance of approx. 5 meters. This corresponds with the viewing of a 1 cm character from 50 cm distance.

With larger characters a closer arrangement is sometimes desirable. It is as though viewers of large displays consider that the proportionally increased separations make the characters appear isolated.

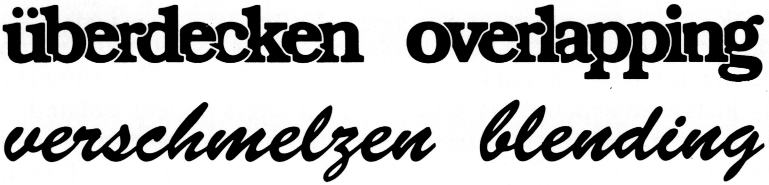
Our letter spacing in this case has the following conception: The user defines in a parameter how far he wishes to approach the touching values. In this 0% means only kerning and 100% means only touching. Values in between allow appropriate interpolation of the two correction values.



Examples of touching

Appendix V
Overlapping table

The overlapping tables have the same structure as kerning tables. They contain however such large negative correction values for character pairs that the two letters overlap. This may be used on the one hand for overlapping whereby a white line outlines the character which is intended to overlap another character. On the other hand one can blend the characters into one another, leaving out the white outlines. Blending or overlapping has absolutely nothing to do with normal typesetting of text, and it is normally used in the development of logos and signets or when creating special effects.

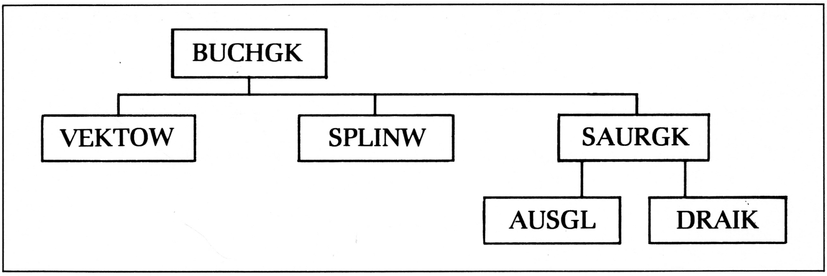


Examples of overlapping and blending

Appendix W
Programs for converting IK→DI

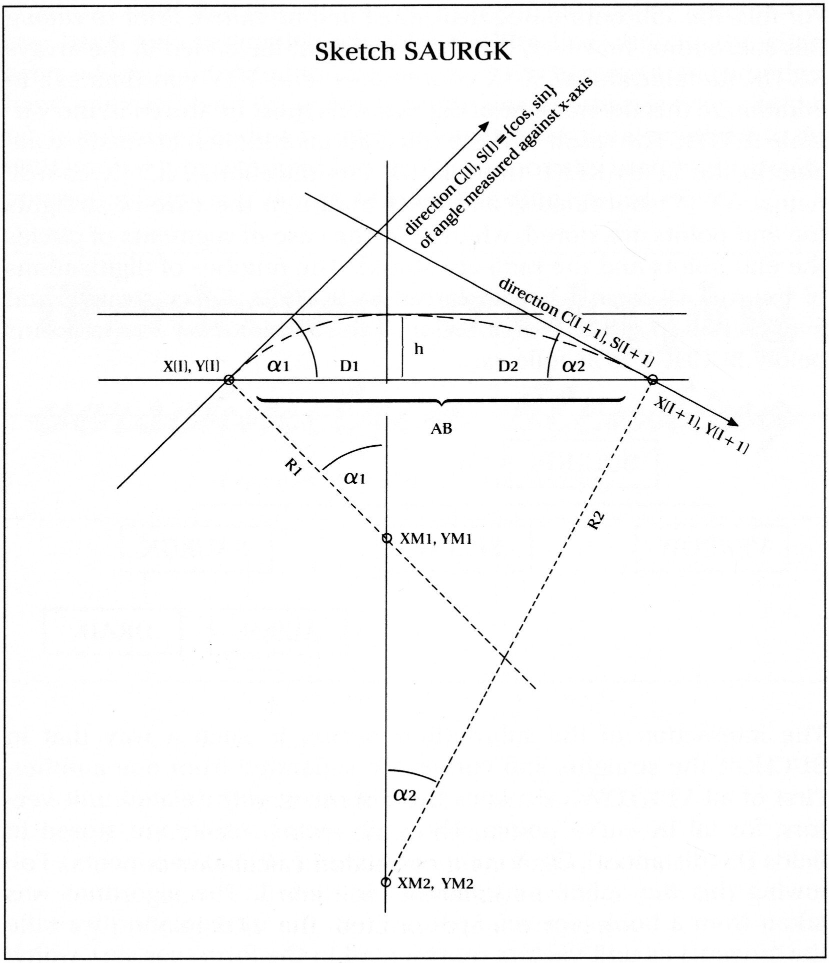
This appendix includes subroutines which convert the IKARUS format into the DISPLAY format.

For this, the subroutine BUCHGK must first be called. Prior to calling this subroutine, however, the character must be loaded in the arrays KE (IK identifications), X (X coordinates) and Y (Y coordinates). In addition to this the number of digitizations must be stored in the variable IKTOT. The result of these calculations can then be made available in the fields KEKE (internal DI identifications), XX (X coordinates), YY (Y coordinates) and RAD (radii). In the case of straights the end points are stored, whereas in the case of segments of circles the end points and the radii are stored. The number of digitizations of internal DI format is transferred in IKTOT2. Every straight and every circle counts as a digitization. The call hierarchy for programs below BUCHGK is as follows:



The interaction of the subroutines occurs in such a way that in BUCHGK the straights and curves are separated from one another. First of all VEKTOW calculates the distances, with related unit vectors, for all IK curve points. The unit vector results are stored in fields DS (distances), C0 (X components) and S0 (Y components). Following this the spline interpolation is started. The algorithm was taken from a book (see ref. Späth). From the interpolation we take the tangents as unit vectors represented in the form (cos,sin), which

are transferred into field C (X components) and S (Y components) to SAURGK.
The calculation of the circle segment is based on the method as used by the ARISTO company for CAD. The following sketch is intended to show the method of calculation with which one identifies the two radii R1 and R2 of the circle segments.


Sketch SAURGK
direction C[I], S[I]={cos, sin}
of angle measured against x-axis
direction C[I+1], S[I+1]
X[I], Y[I]
α1
D1
h
D2
α2
X[I+1], Y[I+1]
AB
R1
α1
XM1, YM1
R2
α2
XM2, YM2

Method of calculations

Looking for those two circles which have the given directions in the two points respectively and which join with the direction given by the connection of the two points. One can write down the following:

$$\left.\begin{array}{l} ①\ AB = D1 + D2 \\ ②\ \sin\alpha_1 = \frac{D1}{R1} \\ ③\ \sin\alpha_2 = \frac{D2}{R2} \\ ④\ \cos\alpha_1 = \frac{R1-h}{R1} \\ ⑤\ \cos\alpha_2 = \frac{R2-h}{R2} \end{array}\right\}$$

One has five equations for five unknowns: D1, D2, R1, R2, h

⑥ ➔ SOLVE: ①+②+③:

$$AB = R1 \cdot \sin\alpha_1 + R2 \cdot \sin\alpha_2$$

④+⑤: $h = R1\,(1-\cos\alpha_1) = R2\,(1-\cos\alpha_2)$

⑦ $$\frac{R1}{R2} = \boxed{DR = \left(\frac{1-\cos\alpha_2}{1-\cos\alpha_1}\right)}$$

⑧ out of ⑥ make: $AB = R2 \cdot \frac{R1}{R2}\sin\alpha_1 + R2 \cdot \sin\alpha_2$

$$= R2\,(DR \cdot \sin\alpha_1 + \sin\alpha_2)$$

$$\Rightarrow \boxed{R2 = AB/(DR \cdot \sin\alpha_1 + \sin\alpha_2)} \Rightarrow \boxed{R1 = DR \cdot R2}$$

The DRAIK routine then has the task of calculating the cos and sin of angles 1 and 2 as pictured in the sketch. The AUSGL routine then has the job of preparing a correction calculation in such cases where two circles of very different radii join with one another. On the following pages we have printed the FORTRAN listing in sequence.

INCLUDE-Files for BUCHGK

```
C                               XYCOM.TXT
C
C  Word     Name        Explanation
C ---------------------------------------------------------------------------
C   1       IKMAX       Max. number of digs              |
C   2       IKTOT       Total number of digitisations    |
C   3/4     H(1)        X minimum                        |
C   5/6     H(2)        X maximum                        |  of current IK-figure
C   7/8     H(3)        Position of left side mark       |
C   9/10    H(4)        Position of right side mark      |
C   11..14  H(5),H(6)   not used                         |
C ---------------------------------------------------------------------------
C 1-IKMAX   KE(..)      Markings of IK- digitisations
C ---------------------------------------------------------------------------
C 1-2*IKMAX X(..)       X-values  of IK- digitisations
C ---------------------------------------------------------------------------
C 1-2*IKMAX Y(..)       Y-values of IK- digitisations
C ---------------------------------------------------------------------------
C
        COMMON/HCOM/IKMAX,IKTOT,H(6)
        COMMON/KCOM/KE(1)
        COMMON/XCOM/X(1)        Dimension in main program should be IKMAX
        COMMON/YCOM/Y(1)
C
C                               XY2COM.TXT
C
C  Word     Name        Explanation
C ---------------------------------------------------------------------------
C   1       IKMAX2       Max. number of GK points        |
C   2       IKTOT2       Total number of GK points       |
C   3/4     HH(1)        X minimum                       |
C   5/6     HH(2)        X maximum                       |  of GK-figure
C   7/8     HH(3)        Position of left side mark      |
C   9/10    HH(4)        Position of right side mark     |
C   11..14  HH(5),HH(6)  not used                        |
C ---------------------------------------------------------------------------
C 1-IKMAX2  KEKE(..)     Markings of GK- points
C ---------------------------------------------------------------------------
C 1-2*IKMAX2 XX(..)      X-values  of GK points
C ---------------------------------------------------------------------------
C 1-2*IKMAX2 YY(..)      Y-values of  GK points
C ---------------------------------------------------------------------------
C
        COMMON/HHCOM/IKMAX2,IKTOT2,HH(6)
        COMMON/KKCOM/KEKE(1)
        COMMON/XXCOM/XX(1)      Dimension in main program should be IKMAX2
        COMMON/YYCOM/YY(1)
C                               DCSCOM.TXT
        COMMON/COCOM/CO(1)
        COMMON/SOCOM/SO(1)      Dimension in main program should be IKMAX
        COMMON/DSCOM/DS(1)
C                               CSGCOM.TXT
        COMMON/CCOM/C(1)
        COMMON/SCOM/S(1)        Dimension in main program should be IKMAX
        COMMON/GCOM/G(1)
C                               GKCOM.TXT
        COMMON/DXCOM/X(1)
        COMMON/DYCOM/Y(1)       Dimension in main program should be IKMAX2
        COMMON/RADCOM/RAD(1)
```

```
C
C                  *******************************
C                  * I K A R U S - L I B R A R Y *
C                  *    S U B R O U T I N E      *
C                  *******************************
C
C
C
C-  Name:               BUCHGK.FOR
C
C-  Keywords:           IK/GK/CONTOUR/FIGURE/SECTION/CURVE/SPLINE/CALCULATE
C
C-  Short Description:  Converts IK format into GK format
C
C-  Call:               CALL BUCHGK(ISTA)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Input-Parameters:   IKTOT                - Number of IK digs
C                       H                    - as usual
C                       IKMAX2               - max. number of GK digs
C-  Input-Data:         X,Y,KE               - as usual ( IK format)
C-  Output-Parameters:  IKTOT2               - Number of GK digs
C                       HH                   - Copy of H
C-  Output-Data:        XX,YY,KEKE,DX,DY,RAD - as usual ( GK format)
C-  Status:             ISTA                 - 0 : OK
C                                              1 : max. number of GK digs
C                                                  exeeded (Overflow)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Subroutine Calls:   VEKTOW,SPLINW,SAURGK
C-  Includes:           XYCOM.TXT,XY2COM.TXT,CSGCOM.TXT
C-  Devices:            -
C-  Author:             R.RADTKE  E.LEHMANN H.STANGE
C-  Date:               00-NOV-84 5-FEB-85  21-AUG-85
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Description:        BUCHGK converts IK character into a GK character
C                       ( with straight segments and circle segments
C
C-  Algorithm:          SAUR  method
C-  Commentary:         In VEKTOW,SPLINW and SAURGK the commons  DSCOM, COCOM
C                       and SOCOM, for the GK format the commons DXCOM, DYCOM
C                       and RADCOM  are used. DSCOM, COCOM, SOCOM have to be
C                       dimensioned in the main program with dimension IKMAX
C                       all others with IKMAX2
C-  Interne Variable:   J   - pointer for GK data
C
C*******************************************************************************
C
        SUBROUTINE BUCHGK(ISTA)
C
        IMPLICIT INTEGER*2 (I-N)
        INCLUDE 'XYCOM.TXT'
        INCLUDE 'XY2COM.TXT'
        INCLUDE 'CSGCOM.TXT'
C
        PARAMETER ( KE12=12, KE13=13, KE14=14, KE15=15 )
        PARAMETER ( LA1=1, LA2=2)
```

```
C
        ISTA = 0
C
        DO 20 I=1,6
           HH(I) = H(I)
 20     CONTINUE
C
        IF(IKTOT.LE.1) THEN
                IKTOT2 = IKTOT
                IF(IKTOT.EQ.1) THEN
                        XX(1) = X(1)
                        YY(1) = Y(1)
                        KEKE(1) = KE12 + LA1*16
                END IF
                GOTO 500
        END IF
C
        I = 1
        J = 0
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C               T h e   b i g   l o o p
C
  100   CONTINUE
        IF (KE(I).NE.KE14) THEN                  ! check for curve points
C
C               S t r a i g h t   s e g m e n t s
C
                J = J + 1
                IF(J.EQ.IKMAX2) THEN
                        ISTA = 1
                        GOTO 500
                END IF
C
                IF (KE(I).EQ.KE12) THEN
                        I12 = I                          ! start points
                        KEKE(J) = KE12 + LA1*16
                   ELSE
                        KEKE(J) = KE(I) + LA2*16
                ENDIF
C
                XX(J) = X(I)
                YY(J) = Y(I)
C
           ELSE
C
C               c u r v e   s e g m e n t s
C
                IANF=I-1
  400           CONTINUE
                IF (I.NE.IKTOT) THEN
                    I=I+1                        ! Loop over curve points
                    IF (KE(I).EQ.KE14) GOTO 400
C
                    IF (KE(I).LT.KE13) I=I-1
                ENDIF
C
                IEND=I
C
C            Calculate distances between IK points
C
                CALL VEKTOW(IANF,IEND,I12,IKTOT,X,Y,KE)
```

```
C
C           Calculate tangent directions
C
               CALL SPLINW(IANF,IEND,I12,IKTOT,X,Y,KE,C,S,G)
C
C           Transformation of a curve into GK format
C
               CALL  SAURGK(IANF,IEND,J,ISTA)
C
               IF(ISTA.EQ.1) GOTO 500
        END IF
C
        I = I + 1
        IF (I.LE.IKTOT) GOTO 100
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
        IKTOT2 = J
C
 500    CONTINUE
        RETURN
        END


C                    ******************************
C                    * I K A R U S - L I B R A R Y *
C                    *   S U B R O U T I N E      *
C                    ******************************
C
C
C
C-  Name:                VEKTOW.FOR
C
C-  Keywords:            SSR/VECTOR/DISTANCE/CALCULATE
C
C-  Short Description:  Calculates distances and unit vectors for SPLINW
C
C-  Call:                CALL VEKTOW(IANF,IEND,I12,IKTOT,X,Y,KE)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 
C
C-  Input-Parameters:    -
C-  Input-Data:          IANF,IEND  Number of first,last point of contour
C                        I12        Number of last start point
C                        IKTOT      Total number of digs
C                        KE,X,Y     as usual
C-  Output-Parameters:   -
C-  Output-Data:         DS         Array with distances
C                        CO,SO      Arrays with unit vectors
C-  Status:              -
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 
C
C-  Subroutine Calls:    -
C-  Includes:            -
C-  Devices:             -
C-  Author:              R.RADTKE  E.LEHMANN H.STANGE  H.STANGE
C-  Date:                20-NOV-84 30-JAN-85 26-MAR-85 08-MAY-85
C
```

```
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Description:        VEKTOW determines the distances and unit vectors between
C                       successive points of a curve of an IK-character
C
C-  Algorithm:          -
C-  Commentary:         The commons DSCOM,COCOM and SOCOM are used . They have
C                       to be dimensioned in the main programm with dimension
C                       IKMAX.
C-  Interne Variable:   -
C
C*****************************************************************************
C
        SUBROUTINE VEKTOW(IANF,IEND,I12,IKTOT,X,Y,KE)
C
        IMPLICIT INTEGER*2 (I-N)
C
        DIMENSION X(1),Y(1),KE(1)
        INCLUDE 'DCSCOM.TXT'
C
        PARAMETER ( KE13 = 13, KE15 = 15)
C
        I=IANF                          ! Start index if first point is or is
        IF (KE(IANF).EQ.KE15) I=I-1     ! not a tangent point
        K=IEND
        GOTO 200
C
  100   CONTINUE
        DXI=X(I1)-X(I)
        DYI=Y(I1)-Y(I)
        DS(I)=SQRT(DXI*DXI+DYI*DYI)     ! distance
        IF (DS(I).LT.1.) THEN
            CO(I)=1.
            SO(I)=0.
        ELSE
            CO(I)=DXI/DS(I)             ! x-component unit vectors
            SO(I)=DYI/DS(I)             ! y-component unit vectors
        ENDIF
C
        I=I1
  200   CONTINUE
        I1=I+1
        IF (I.NE.K) GOTO 100
C
        IF (KE(IEND).EQ.KE15.AND.K.EQ.IEND) THEN
C
C           end point is a tangent point
C
            IF (IEND.EQ.IKTOT.OR.KE(IEND+1).LT.KE13) I1=I12+1
            K=I1
            GOTO 100
        ENDIF
        RETURN
C
        END
```

```
C
C                  *******************************
C                  * I K A R U S - L I B R A R Y *
C                  *    S U B R O U T I N E      *
C                  *******************************
C
C
C
C-  Name:               SPLINW.FOR
C
C-  Keywords:           SSR/IK/FIGURE/CONTOUR/SPLINE/TANGENT/CALCULATE
C
C-  Short Description:  Calculates tangents
C
C-  Call:               CALL SPLINW(IANF,IEND,I12,IKTOT,X,Y,KE,C,S,G)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Input-Parameters:   IANF,IEND     - Number of first/last point of curve
C                       I12           - Number of last start point
C                       IKTOT         - as usual
C-  Input-Data:         X,Y,KE        - as usual
C                       DS            - Array with distance ( from VEKTOW )
C                       CO,SO         - Arrays with unit vectors ( from VEKTOW )
C-  Output-Parameters:  -
C-  Output-Data:        C,S,G         - Unit vectors in direction of tangents
C-  Status:             -
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Subroutine Calls:   -
C-  Includes:           -
C-  Devices:            -
C-  Author:             R.RADTKE  E.LEHMANN  H.STANGE
C-  Date:               20-NOV-84 30-JAN-85  15-MAY-85
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Description:        SPLINW determines tangential unit vectors for specified
C                       curve points considering different parameters using
C                       cubic polynom splines.
C
C-  Algorithm:          -
C-  Commentary:         Commons DSCOM,COCOM and SOCOM are used. They have to be
C                       dimensioned in the main program with diemsnion IKMAX
C-  Interne Variable:   TOL = tolerance for closed contours
C
C******************************************************************************
C
        SUBROUTINE SPLINW(IANF,IEND,I12,IKTOT,X,Y,KE,C,S,G)
C
        IMPLICIT INTEGER*2 (I-N)
        DIMENSION X(1),Y(1),KE(1),C(1),S(1),G(1)
        INCLUDE 'DCSCOM.TXT'
C
        PARAMETER ( KE13 = 13, KE14 = 14, KE15 = 15, TOL=100.)
C
        N1=IEND-1
        K=IANF
```

```
C
        IF (KE(IANF).EQ.KE15) THEN      ! First IK-point is a tangent point
            KA=IANF+1
            G(IANF)=0.0
            C(IANF)=CO(IANF-1)
            S(IANF)=SO(IANF-1)
        ELSE                            ! First IK-point is not a tangent point
            KA=IANF
            G(IANF)=0.5
            C(IANF)=1.5*CO(IANF)        ! end curvature in x is 0
            S(IANF)=1.5*SO(IANF)        ! end curvature in y is 0
        ENDIF
C
C         Calculation of tangent directions
C
  100   CONTINUE
        H2=1.
        IF(DS(K).GT.0.1) H2 = 1./DS(K)
        C2=3.*CO(K)*H2
        S2=3.*SO(K)*H2
        IF (K.NE.IANF) THEN
            Z=1./(2.*(H1+H2)-H1*G(K1))
            G(K)=Z*H2
            C(K)=Z*(C1+C2-H1*C(K1))
            S(K)=Z*(S1+S2-H1*S(K1))
            IF (K.GE.N1) THEN
                IF (KE(IEND).EQ.KE15) THEN   ! End point is a tangent point
                    C(IEND)=CO(IEND)
                    S(IEND)=SO(IEND)
                    C1=C(IEND)
                    S1=S(IEND)
                    C(K)=C(K)-G(K)*C1        ! x-component tangent vector
                    S(K)=S(K)-G(K)*S1        ! y-component tangent vector
                    GOTO 200
                ENDIF
            ENDIF
        ENDIF
C
        C1=C2
        S1=S2
        H1=H2
C
        K1=K
        K=K+1
        IF (K.LT.IEND) GOTO 100
C
        Z=1./(2.-G(N1))
        C(IEND)=Z*(3.*CO(N1)-C(N1))     ! end curvature in X is 0
        S(IEND)=Z*(3.*SO(N1)-S(N1))     ! end curvature in Y is 0
C
  200   CONTINUE
        C1=C(K)
        S1=S(K)
        H2=1./SQRT(C1*C1+S1*S1)
        C(K)=C1*H2                      ! normalize x-component
        S(K)=S1*H2                      ! normalize y-component
        K=K-1
        IF (K.GE.KA) THEN
            C(K)=C(K)-G(K)*C1           ! x-component of tangent vector
            S(K)=S(K)-G(K)*S1           ! y-component of tangent vector
            GOTO 200
        ENDIF
```

```
C
C         Special treatment for closed curves
C
        IF(KE(IEND).EQ.KE14) THEN
            IF((X(IEND)-X(IANF))**2+(Y(IEND)-Y(IANF))**2.LE.TOL) THEN
C
                DXK=C(IANF)+C(IEND)                 ! average x component
                DYK=S(IANF)+S(IEND)                 ! average y-component
                H2=1./SQRT(DXK*DXK+DYK*DYK)
                C(IANF)=DXK*H2                      ! normalize x component
                S(IANF)=DYK*H2                      ! normalize y component
                C(IEND)=C(IANF)
                S(IEND)=S(IANF)
C
            END IF
C
        ELSE IF(KE(IEND).EQ.KE13) THEN
C
C          calculate tangent direction at the end (corner) points
C
                G(IEND-2)=C(IEND)
                G(IEND-1)=S(IEND)
C
             IF((IEND.EQ.IKTOT.OR.KE(IEND+1).LT.KE13).AND.
                (X(IEND)-X(IANF))**2+(Y(IEND)-Y(IANF))**2.LE.TOL) THEN
C
                        C(IEND) = C(I12)
                        S(IEND) = S(I12)
             END IF
        END IF
C
        RETURN
        END


C
C                  *******************************
C                  * I K A R U S - L I B R A R Y *
C                  *    S U B R O U T I N E      *
C                  *******************************
C
C
C-  Name:               SAURGK.FOR
C
C-  Keywords:           SSR/IK/GK/CIRCLES/TANGENT/SECTION/ANGLE/CALCULATE
C
C-  Short Description: Calculates sections of circles or lines between IK points
C
C-  Call:               CALL SAURGK(IANF,IEND,J,ISTA)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Input-Parameters:   IANF,IEND       - Number of first/last point of a curve
C                       J               - Pointer for GK  data
C                       IKMAX2          - Max. number of GK  digs
C-  Input-Data:         X,Y,KE          - as usual ( in IK format )
C                       C,S,G           - as usual
C                       DS,CO,SO        - Data from VEKTOW
C-  Output-Parameters:  J               - see above
C-  Output-Data:        XX,YY,KEKE,     - Contour ( in GK format )
C                            DX,DY,RAD
```

```
C-  Status:         ISTA            - 0 : OK
C                                         1 : Max. number of GK digs exeeded
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Subroutine Calls:   DRAIK (determines cosine and sine of angle between
C                       tangents and link between two sucessive IK points)
C                       AUSGL (corrects skewed triangles)
C
C-  Includes:           XYCOM.TXT,XY2COM.TXT,CSGCOM.TXT,DCSCOM.TXT,GKCOM.TXT
C-  Devices:            -
C-  Author:             R.RADTKE  E.LEHMANN H.STANGE
C-  Date:               00-NOV-84 4-FEB-85  13-MAR-85
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Description:
C-  Beschreibung:       SAURGK displays a curve of an IK character by matching
C                       circle segments in GK format
C
C-  Algorithm:          SAUR  method
C-  Commentary:         Commons DSCOM,COCOM and SOCOM are used. They have to
C                       be dimensioned in the main programm
C-  Interne Variable:   -
C*******************************************************************************
C
        SUBROUTINE SAURGK(IANF,IEND,J,ISTA)
C
        IMPLICIT INTEGER*2 (I-N)
        INCLUDE 'XYCOM.TXT'
        INCLUDE 'XY2COM.TXT'
        INCLUDE 'CSGCOM.TXT'
        INCLUDE 'DCSCOM.TXT'
        INCLUDE 'GKCOM.TXT'
C
        PARAMETER (LA2=2, LA3=3, LA4=4)
        ISTA = 0
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
        I=IANF+1
        CI1=C(IANF)
        SI1=S(IANF)
        CI=C(I)
        SI=S(I)
        CS=CO(IANF)
        SS=SO(IANF)
        CALL DRAIK(CS,SS,CI1,SI1,CI,SI,SA1,SA2,CA1,CA2,IN)
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C                       New run
  100   CI2=C(I+1)
        SI2=S(I+1)
        CSS=CO(I)
        SSS=SO(I)
        CALL DRAIK(CSS,SSS,CI,SI,CI2,SI2,SA11,SA22,CA11,CA22,INN)
        IF (IN.EQ.0) THEN
            J = J + 1
            IF(J.EQ.IKMAX2) THEN
                ISTA = 1
                RETURN
            END IF
C
```

```
        KEKE(J) = KE(I) + LA2*16       ! bad triangle
            XX(J) = X(I)                   ! linear interpolation
            YY(J) = Y(I)
            GOTO 500
        ENDIF
C
        IF(INN.EQ.0) THEN
            CI=CSS
            SI=SSS
            CI2=CSS                         ! second triangle is bad, one
            SI2=SSS                         ! more chance
            GOTO 200
        ENDIF
C
        IF(IN*INN.LT.0) GOTO 400        ! triangles have different sense of
C                                         rotation, no correction possible
        CALL AUSGL(IN,SA1,SA2,SA11,SA22,CI,SI,IAUS)
        IF(IAUS.EQ.0) GOTO 400          ! Correction was not successful
C
C               Apply correction or (200) save second triangle
C
        CALL DRAIK(CSS,SSS,CI,SI,CI2,SI2,SA11,SA22,CA11,CA22,INN)
  200   CALL DRAIK(CS,SS,CI1,SI1,CI,SI,SA1,SA2,CA1,CA2,IN)
  300   CONTINUE
        IF (IN.EQ.0) THEN
            J = J + 1
            IF(J.EQ.IKMAX2) THEN
                ISTA = 1
                RETURN
            END IF
C
            KEKE(J) = KE(I) + LA2*16       ! bad triangle
            XX(J) = X(I)                   ! linear interpolation
            YY(J) = Y(I)
            GOTO 500
        ENDIF
C
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C       Now it is time to fit the circles (only if radii are reasonable)
C
C-----------------------------------------
 400    DR=(1.-CA2)/(1.-CA1)             !
        R2=DS(I-1)/(DR*SA1+SA2)          !
        R1=DR*R2                         !
C-----------------------------------------
        IF(R2.LT.10..OR.R1.LT.10..OR.R1.GT.5E5.OR.R2.GT.5E5) THEN
            J = J + 1
            IF(J.EQ.IKMAX2) THEN
                ISTA = 1
                RETURN
            END IF
C
            KEKE(J) = KE(I) + LA2*16       ! bad triangle
            XX(J) = X(I)                   ! linear interpolation
            YY(J) = Y(I)
        ELSE
            IF(IN.LE.0) THEN
                R1 = -R1
                R2 = -R2
            ENDIF
```

```
C
C       Point I-1 relativ to centre of first circle
C
            XM1 = X(I-1) - R1*SI1
            YM1 = Y(I-1) + R1*CI1
            DX1 = X(I-1) - XM1
            DY1 = Y(I-1) - YM1
C
C         Auxiliary point
C
            XH=X(I-1)+R1*(SS-SI1)
            YH=Y(I-1)+R1*(CI1-CS)
C
C         Auxiliary point relative to centre of second circle
C
            DX2 = XH - (X(I) - R2*SI)
            DY2 = YH - (Y(I) + R2*CI)
C
            LA = LA3
            IF(IN.GT.0) LA = LA4
C
C         Store auxiliary point and (DX1,DY1)
C
            J = J + 1
            IF(J.EQ.IKMAX2) THEN
                ISTA = 1
                RETURN
            END IF
            KEKE(J) = LA*16
            XX(J) = XH
            YY(J) = YH
            DX(J) = DX1
            DY(J) = DY1
            RAD(J) = ABS(R1)
C
C        Store curve end points and (DX2,DY2)
C
            J = J + 1
            IF(J.EQ.IKMAX2) THEN
                ISTA = 1
                RETURN
            END IF
            KEKE(J) = KE(I) + LA*16
            XX(J) = X(I)
            YY(J) = Y(I)
            DX(J) = DX2
            DY(J) = DY2
            RAD(J) = ABS(R2)
C
        ENDIF
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C               Final procedure
C
  500   IF (I.NE.IEND) THEN
            IN=INN
            SA1=SA11
            SA2=SA22
            CA1=CA11
            CA2=CA22
            CS=CSS
            SS=SSS
            CI1=CI
        SI1=SI
            CI=CI2
            SI=SI2
            I=I+1
            IF (I.LT.IEND) THEN
                 GOTO 100
            ELSE
                 GOTO 300
            ENDIF
        ENDIF
C- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
        RETURN
        END


C
C                  ******************************
C                  * I K A R U S - L I B R A R Y *
C                  *   S U B R O U T I N E       *
C                  ******************************
C
C
C
C-  Name:               DRAIK.FOR
C
C-  Keywords:           SSR, ANGLE, TRIANGLE, CALCULATE
C
C-  Short Description:  DRAIK checks triangles and calculates base angles
C
C-  Call:               CALL DRAIK(CS,SS,CI1,SI1,CI,SI,SA1,SA2,CA1,CA2,IDREH)
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Input-Parameters:   (CS,SS)   -   Direction of triangle basis
C                       (CI1,SI1) -        "      left arm
C                       (CI,SI)   -               right arm
C-  Input-Data:         -
C-  Output-Parameters:  SA1,SA2   -   Sine of both base angles
C                       CA1,CA2   -   Cosine   "    "     "
C                       IDREH      -  Sense of turn
C-  Output-Data:        -
C-  Status:             -
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Subroutine Calls:   -
C-  Includes:           -
C-  Devices:            -
C-  Author:           ?     H.STANGE
C-  Date:         00-JAN-00 02-NOV-84
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Description:
C-  Beschreibung:     DRAIK checks triangles and calculates base angles
C
C                     IDREH =  1, when triangle o.k., when math. right
C                     IDREH = -1, when triangle o.k., when math. left
C
C                     IDREH =  0, when not o.k.
```

```
C
C-  Algorithm:          -
C-  Commentary:         -
C-  Interne Variable:  -
C
C**********************************************************************
C
        SUBROUTINE DRAIK(CS,SS,CI1,SI1,CI,SI,SA1,SA2,CA1,CA2,IDREH)
C
C
        IMPLICIT INTEGER*2 (I-N)
C
        PARAMETER ( TOL = 0.0015 )
C
        IDREH=1
C
C
        SA1=CS*SI1-CI1*SS
        SA2=CS*SI - CI*SS
C
        IF(SA1*SA2.LE.0.) THEN
C
               IF(SA1.GT.0.) IDREH = -1
               SA1=ABS(SA1)
               SA2=ABS(SA2)
C
               IF(SA1.GE.TOL.AND.SA2.GE.TOL) THEN
                      CA1=CS*CI1+SS*SI1
                      CA2=CS*CI +SS*SI
                      IF(CA1.LT..1.OR.CA2.LT..1) IDREH = 0
                  ELSE
                      IDREH = 0
               END IF
C
            ELSE
               IDREH = 0
C
        END IF
C
C
        RETURN
        END



C
C                    ******************************
C                    * I K A R U S - L I B R A R Y *
C                    *    S U B R O U T I N E     *
C                    ******************************
C
C
C
C-  Name:                AUSGL.FOR
C
C-  Keywords:            SSR/TRIANGLE/CHANGE/ANGLE
C
C-  Short Description:  Corrects triangles for program SAURGK
C
C-  Call:                CALL AUSGL(IDREH,SA1,SA2,SA11,SA22,CI,SI,IAUS)
C
```

```
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Input-Parameters:   IDREH          Sense of turn for both triangles
C-  Input-Data:
C                       SA1,SA2        Opening angles of first triangle
C                       SA11,SA22      Opening angles of second triangle
C                       CI,SI          Direction of common section
C-  Output-Parameters:  IAUS = 0       If correction is not necessary
C                            = 1       If correction was applied
C-  Output-Data:        CI,SI          New direction of common section
C-  Status:             -
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C-  Subroutine Calls:-
C-  Includes:-
C-  Devices:-
C-  Author:  NN         E.LEHMANN
C-  Date:  00-JAN-00  4-FEB-85
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C-  Description:
C-  Beschreibung:   AUSGL corrects triangles that are not o.k.
C                   One side of both triangles are placed on one line.
C                   This common direction (CI,SI) is corrected, in order to
C                   make both triangles a little more symmetrical.
C
C                 CI,SI  = common line direction (turned if necessary)
C              -----------------**------------------
C              ^           SA2  .. SA11              ^
C               ^              .   .                 ^
C                ^            .     .                ^
C                 ^          .       .               ^
C                  ^        .         .              ^
C                   ^ SA1  .  <<      >>   . SA22    ^
C                    ^    .     arms        .       ^
C                     ^  .                    .    ^
C                      ^.                       .  ^
C
C               SA1,SA2 ... are sines of angles
C-  Algorithm:-
C-  Commentary:-
C-  Interne Variable:-
C
C******************************************************************************
        SUBROUTINE AUSGL(IDREH,SA1,SA2,SA11,SA22,CI,SI,IAUS)
        IMPLICIT INTEGER*2 (I-N)
C
        IAUS=0
        DR=IDREH*.7
        DEL1=(SA1-SA2)*DR
        DEL2=(SA11-SA22)*DR
        DEL=(DEL1+DEL2)*.7
C
C  DEL = positiv , turn right
C  DEL = negativ , turn left
C
        DELDR=DEL*DR
```

```
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      IF(DELDR.GE.O.) THEN
C
C  SA11 becomes smaller
C
          IF(DELDR.LT..01) RETURN
          IF(DELDR.GT.DEL2*DR) DEL=DEL2
      ELSE
C
C  SA2 becomes smaller
C
          IF(DELDR.GT.-.01) RETURN
          IF(DELDR.LT.DEL1*DR) DEL=DEL1
      ENDIF
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Rotate (CI,SI)
C
      CDEL=SQRT(1.-DEL*DEL)
      C=CI*CDEL-SI* DEL
      SI=CI* DEL+SI*CDEL
      CI=C
C
      IAUS=1
      RETURN
      END
```

Appendix X
Marking rules

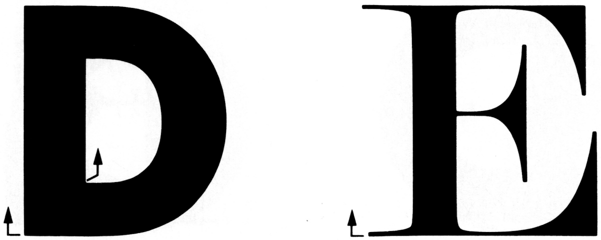
Prior to the proper digitizing procedure, one must prepare the original. This involves marking the digitization points, adjusting the baseline, the left side and right side bearings, and treating of special cases, e.g. digitizing multicolored logotypes.

The results of the digitizing are very dependent upon the number and position of the digitization points. The idea is to achieve the best reproduction of the original with the least number of points. To this end it is recommended to mark the points to be digitized on the original prior to digitization, as follows:

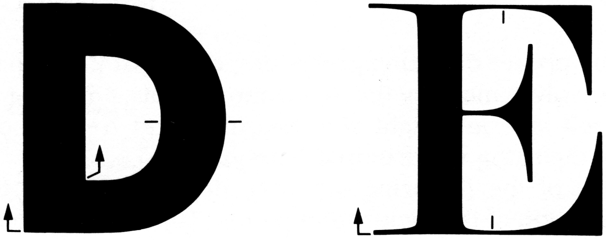
Start points		Show the direction of digitization.
Corner points	—	Need not be marked, they are obvious.
Curve points	–	Extreme points, two or three points within a 90° change of direction, at points of inflection and auxiliary points.
Tangent points	>	Tangent points never occur alone. There are either two tangent points or a neighbouring corner point, in order to define the straight.

First of all the necessary points (e.g. curve extremes and auxiliary points) are marked, followed by the necessary intermediate points, marked as uniformly as possible.

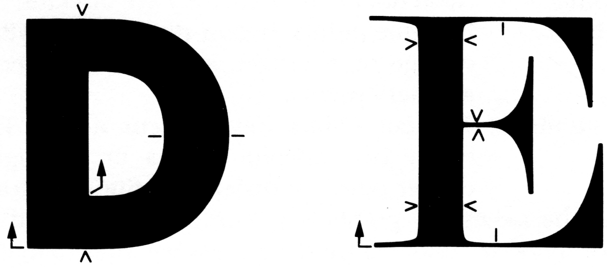
1) Mark in start points



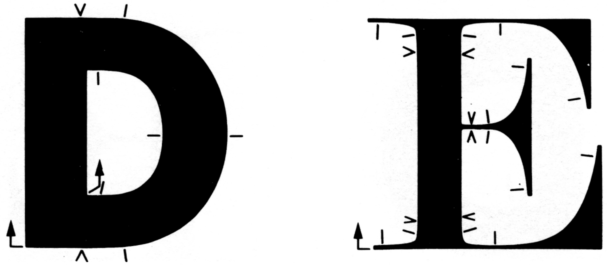
2) Mark in curve extreme points

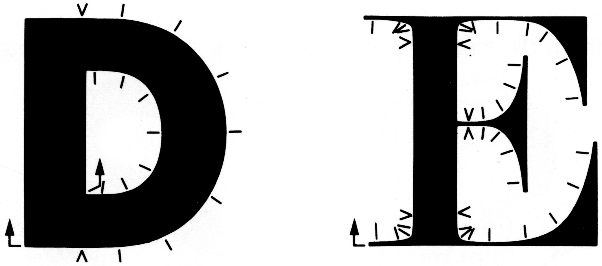


3) Mark in tangent points



4) Mark in aid points

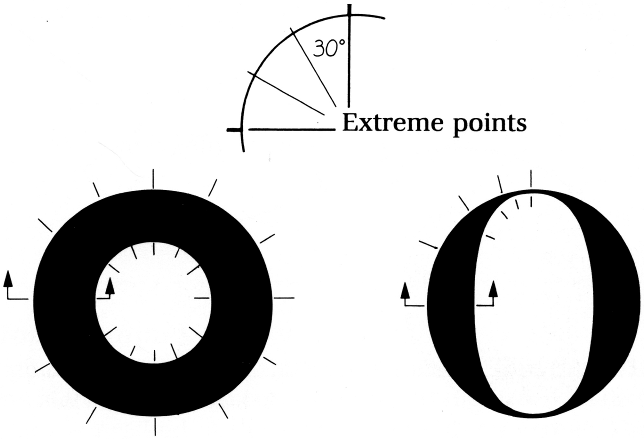




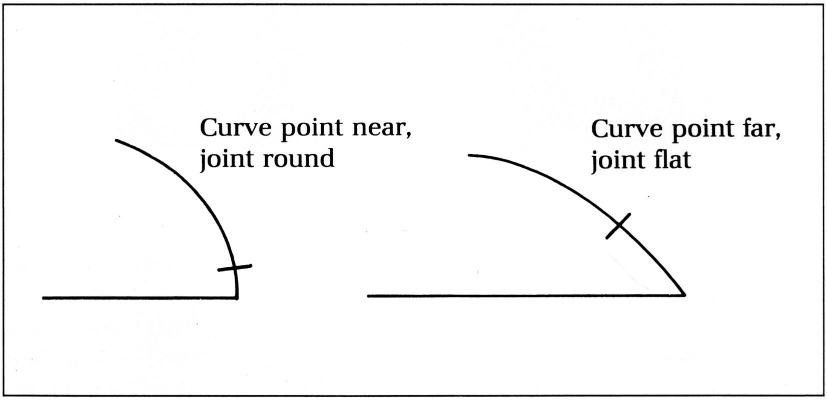
5) Mark in intermediate points

In the following, further marking rules are described using combinations of text and examples.

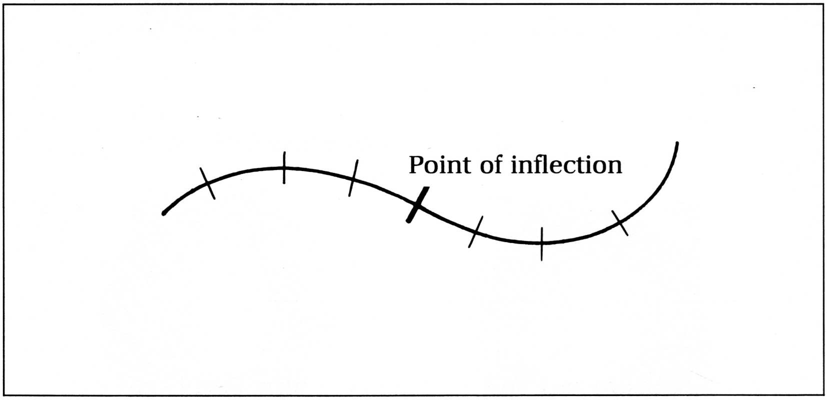
A circle is marked by its extreme points. These points are at the maximum and minimum extension of a curve. With a full circle four curve points suffice for its display. With deviations from ideal circles additional curve points are necessary; two or three additional curve points per 90 degree turn.



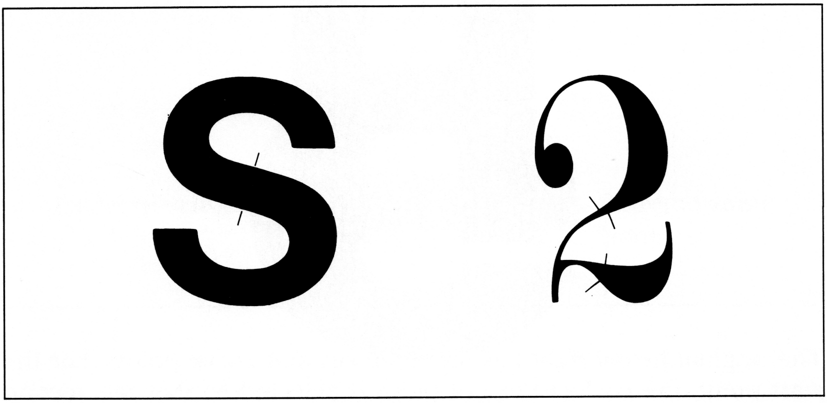
The joint of a curve to a corner requires particular attention. Since only curve points can create a curved line, placing the curved point too far from the joint will produce too flat a curve. For this reason the last curve point must be marked approximately three to five millimeters from the corner point (assuming 100 mm cap height).


Curve point near,
joint round
Curve point far,
joint flat

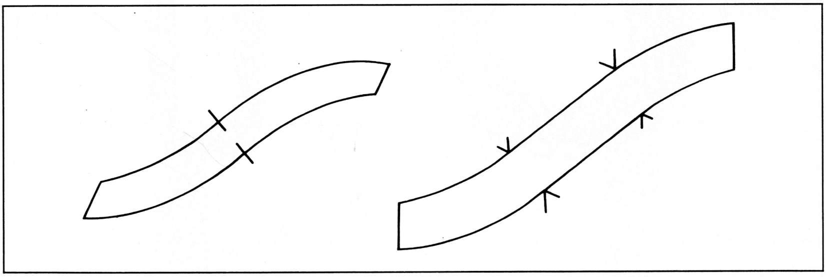
Points of inflection must to be marked with a curve point.


Point of inflection

Point of inflection refers to those positions at which a left curve runs into a right curve or a right curve runs into a left curve.

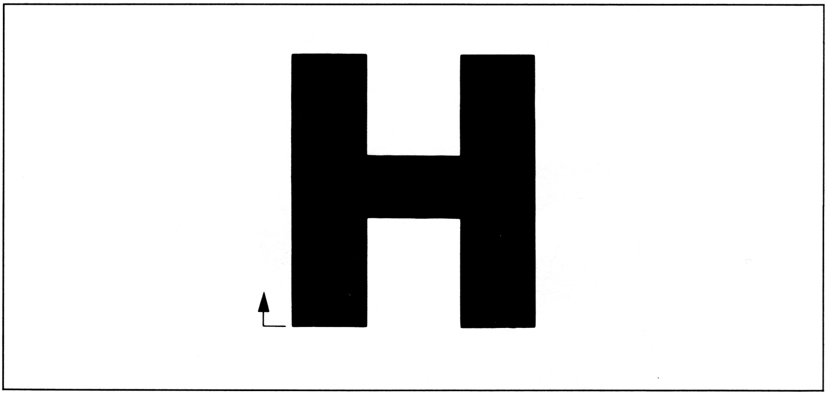


There are examples in graphics where such directional changes do not take place immediately, but where there is a straight segment between two curved sections. In such cases we do not have a point of inflection but a transition from curve into straight and from straight into curve, i.e. tangent points.

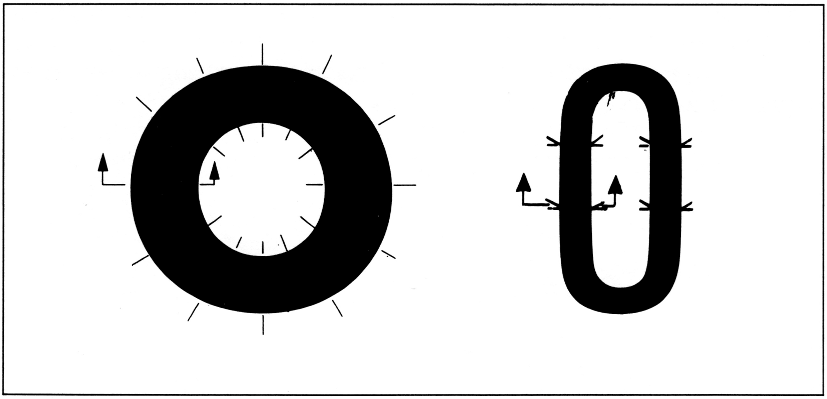


Marking examples

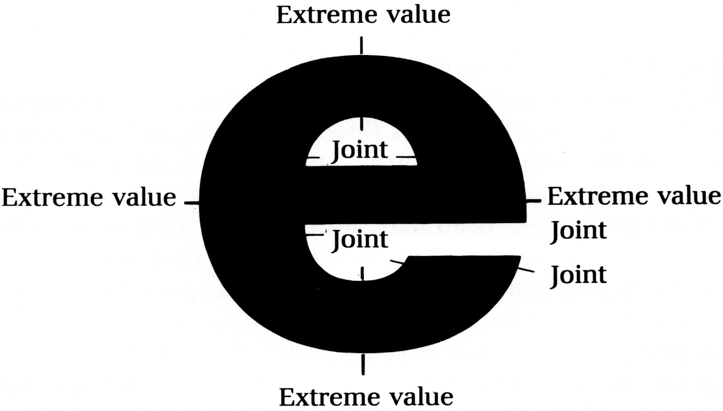
The original below has only straight contours. Correspondingly we have one start and twelve corner points to digitize. The direction of digitization is marked at the start point with an arrow. The corner points do not need to be marked.



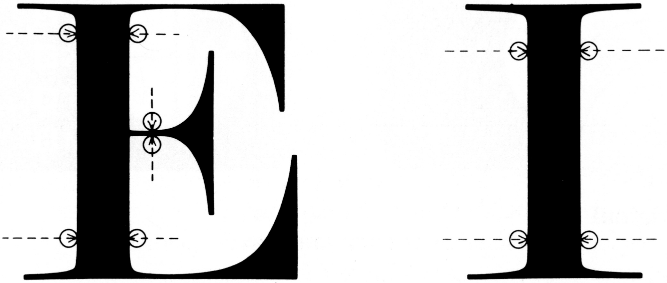
The original below right has only tangent and curve points. For the start point, the correct tangent point is selected so that the second point will also be a tangent point.



This original above left has only curve points. Points should be marked approximately every 30 degrees.
Below original consists of corner and curve points. Notice that the extreme values of the curves have to be marked, and that at the section joining corner to curve, a curve point should be set approximately 3 to 5 mm from the corner.


Extreme value
Joint
Extreme value
Extreme value
Joint
Joint
Joint
Extreme value

Tangent points are marked with >. When dealing with symmetrical sections of the original for example, make sure that the corresponding tangent points are marked at the same height or width.



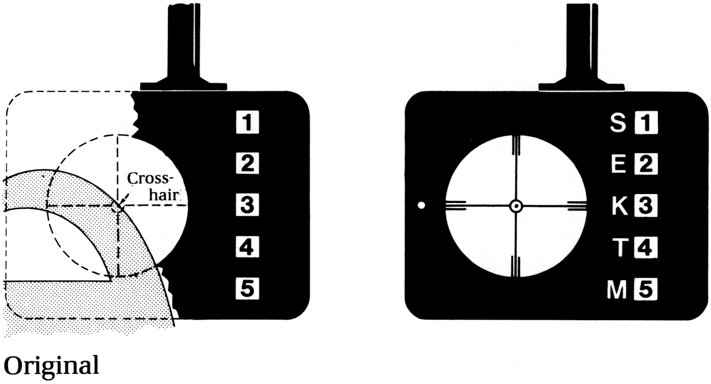
Appendix Y
Digitizing rules

1. Operating the sensor

The sensor of the digitizer has a cross-hair fitted under a magnifying glass, and five sensor keys. It is fitted into a box and interacts electromagnetically with the digitizer tablet. This small device is also popularly known as the “mouse”. In order to avoid misunderstandings, it should be mentioned that the commonly used mouse can just return relative displacement information to its host, whereas a digitizer mouse enables absolute measurements of positions.

Cross-hair

The point where the two hairs cross is lined up on the marked point above the black/white transition of the letter outline. Its current position is input into the computer by pressing the appropriate key for the type of point.

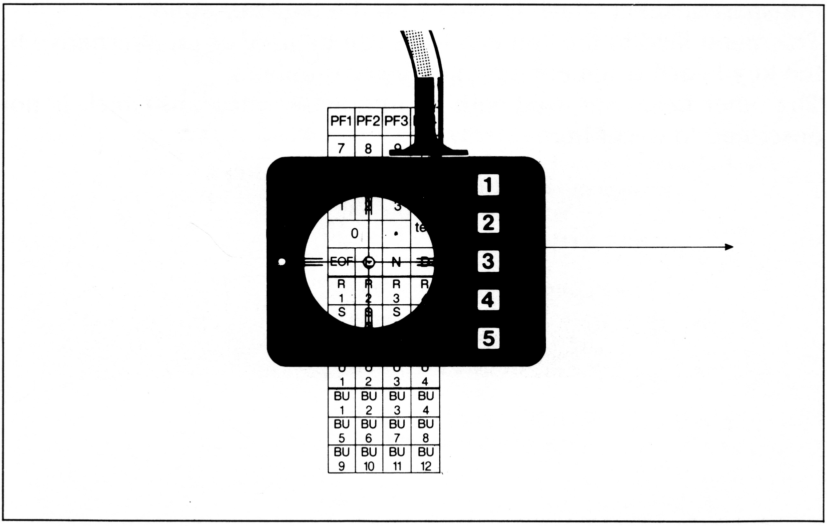


Sensor keys

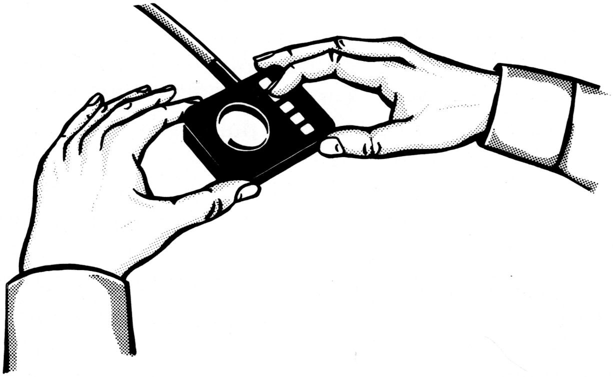
The upper four sensor keys correspond directly to the four individual types of points used to represent the IKARUS format:

s 1 start point
e 2 corner point
k 3 curve point
t 4 tangent point
The last sensor key
m 5 is reserved for the menu field
and initiates the menu command.

In order to select from the menu the cross-hair is approximately lined up with the center of the relevant 1 cm × 1 cm menu box (lining up exactly with the centre of the box is not necessary) and sensor key **m 5** pressed.
The menu commands allow 34 different program functions to be selected for new digitizing and for the correction of digitizations of originals.

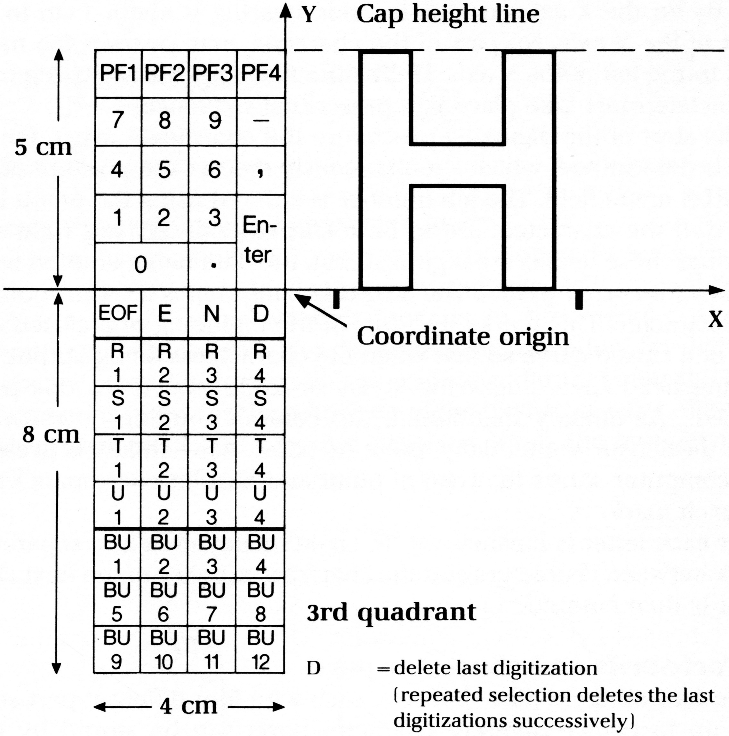

PF1
PF2
PF3
7
8
0
EOF
N
R 1
R 2
R 3
S
S
1
2
3
4
BU 1
BU 2
BU 3
BU 4
BU 5
BU 6
BU 7
BU 8
BU 9
BU 10
BU 11
BU 12
1
2
3
4
5

The sensor is held as shown:



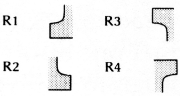
2. Structure of digitizing menu for IKARUS

The axis intersection together with the menu box is marked on a transparent sheet which is placed on the digitizer tablet.
The menu field in the 2nd quadrant can be used as an alternative to the key board when entering character numbers.
The other fields are used with an interactive program which is not described in detail here.


Y
Cap height line
PF1
PF2
PF3
PF4
7
8
9
–
4
5
6
,
1
2
3
En-ter
0
.
5 cm
X
Coordinate origin
EOF
E
N
D
R 1
R 2
R 3
R 4
S 1
S 2
S 3
S 4
T 1
T 2
T 3
T 4
U 1
U 2
U 3
U 4
BU 1
BU 2
BU 3
BU 4
BU 5
BU 6
BU 7
BU 8
BU 9
BU 10
BU 11
BU 12
8 cm
4 cm

3rd quadrant

D = delete last digitization
(repeated selection deletes the last digitizations successively)
N = next character
(≙ end of character mark)
E = end of a font
EOF = end of all digitizations
R = R serif of e.g.



S = S serif
T = T serif
U = U serif
BU1... ...BU12 = character parts of numbers 1 to 12

3. Digitizing

The first character original is fixed under the plastic sheet with adhesive tape or on register pins in such a manner that its baseline rests exactly on the X axis and the left side bearing is about 1 cm to the right of the Y axis. No part of the character may overlap the menu field to the left of the Y axis. Unlike the marking, the digitizing of all characters must take place in a prescribed sequence.

At the start of the digitizing procedure the coordinate origin for the font is determined, which simultaneously defines the position of the IKARUS menu field. The job number is entered using the menu keyboard. If the characters are to be recorded with left and right side bearings these details are digitized first, the data being entered using the key for corner points. The next digitizing step is the start point of the character. This marks the start of the digitizing of a closed outline or a closed curve so that when the character is being output, the writing head (pen, engraving stylus or knife) moves to this point "raised". As already mentioned, the contour (outline) is recorded with the sensor sequentially, point by point. As each key is pressed, the computer stores the type of point and absolut coordinate value for each mark.

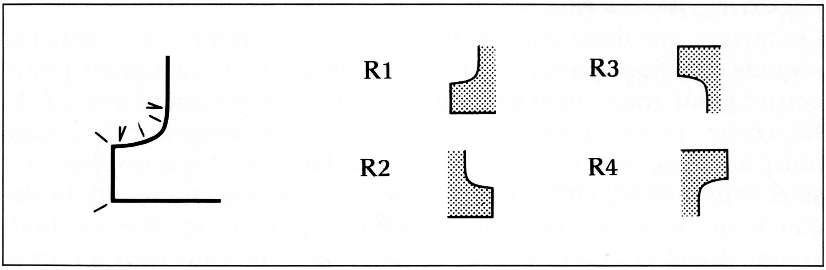
After each letter is finished, an "N" (next) is keyed in as a separating mark between characters and the character number of the next character is then entered.

4. Part-serifs and character parts

Up to four different part-serif sets, each with four different part-serifs and up to twelve different character parts can be stored by processing steps.

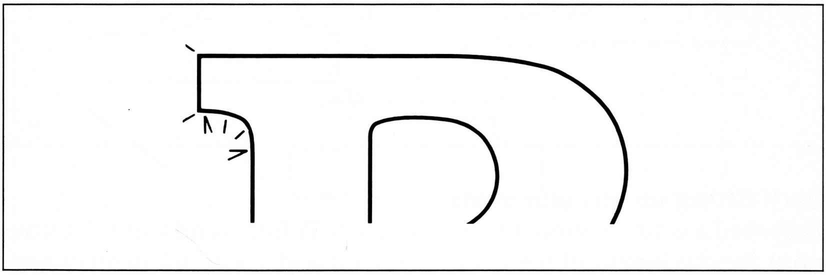
Storing part-serifs

One needs to digitize only the R1 or S1, T1 or U1 serif, paying attention that one always "digitizes from the serif to the straight", because the program always assumes that all parts of serifs are digitized as if they were positioned on vertical stems. Prior to the recording of part-serifs the appropriate menu command must be given. The program calculates the part-serifs 2, 3 and 4 automatically as mirror images at Y axis, at X axis and as rotation by 180 degrees, and stores them ready for recall via other menu commands.



Recording and fitting of character parts

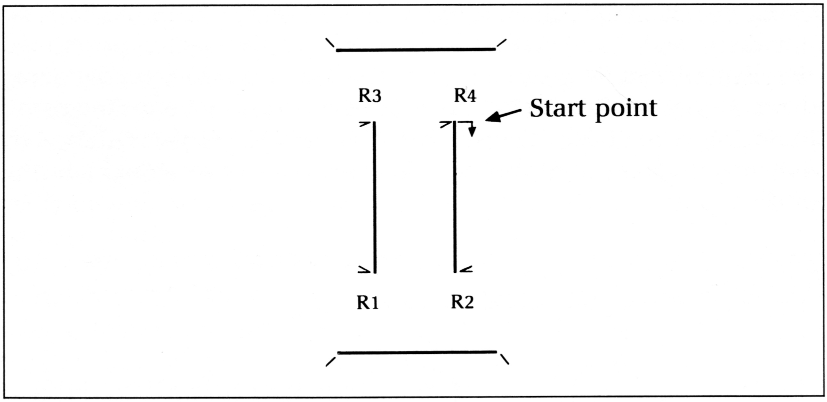
The term “character parts” refers to parts similar to serifs (incomplete, characteristic letter forms, repeated regularly throughout an alphabet), and has relevant commands in the menu positioned directly under those given for the serifs. The procedure for digitizing character parts differs from that of serifs in so far that after the menu command is given for the recording of the character parts, they start with a start point and they are digitized “from the straight to the serif”.



In contrast to serifs, character parts also have to be digitized at the correct Y height. One must make sure that the last point (here a corner point) in the X direction allows the direction of fitting to be recognized. Directions of fitting are “to the right” and “to the left”. This shift only takes place in the X direction, i.e. the character part must be digitized for recording at the correct Y height. Prior to digitizing the character part, the appropriate menu command (BU1 to BU12) must be given.

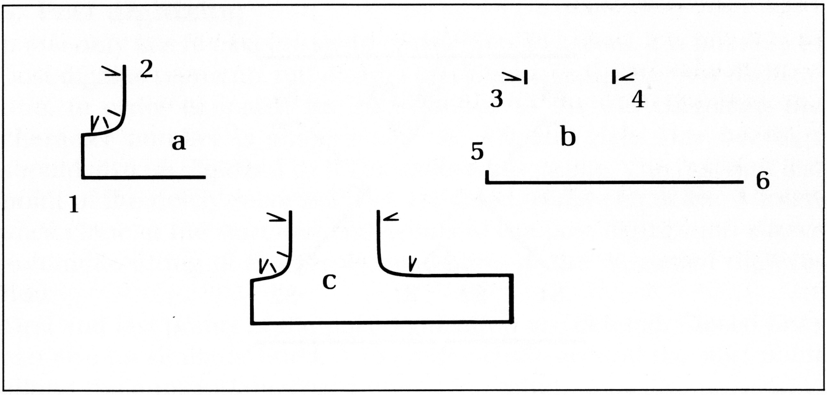
Digitizing part-serifs

Characters are dealt with in the following manner: The digitizing sequence is: Start point, tangent point, menu field R2, corner point, corner point, menu field R1, tangent point, tangent point, menu field R3, corner point, corner point, menu field R4, tangent point. Care must be taken to ensure that the digitizing of a character does not start with a menu command or end with a menu command. In the course of the further processing (channel processing), the two horizontal straights of the "I" (for example) are lined up with the base line and the cap height line respectively. Afterwards the serifs are fitted using the program DV.

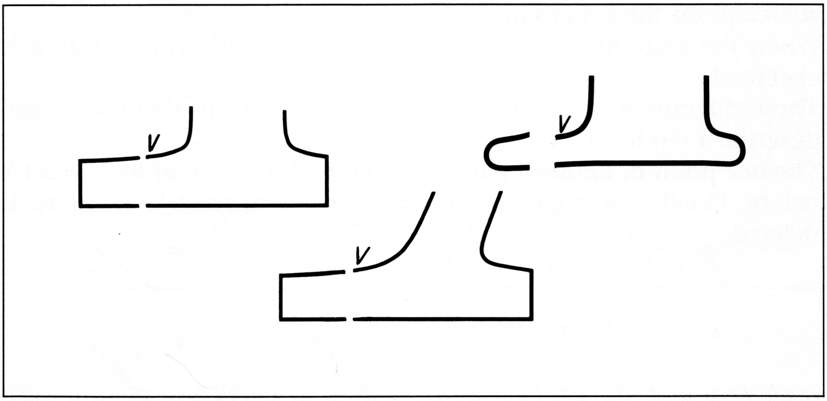


Serif fitting on straight stems

Part-serif a is to be fitted onto character b. Points 5 and 6 are determinant for the length of the serifs, points 3 and 4 are not determinant with respect to their Y position, which is taken from part a (serif height is defined by point 2). The curved segment of the serif is retained, the extension lies between corner and tangent point. The result is character part c.



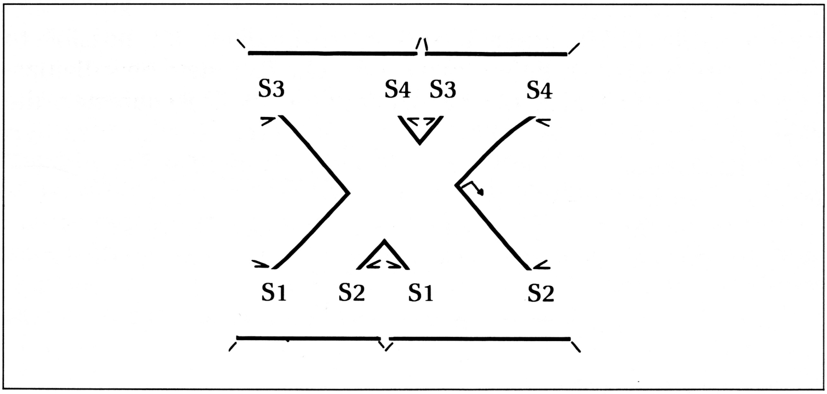
Other fitting results:



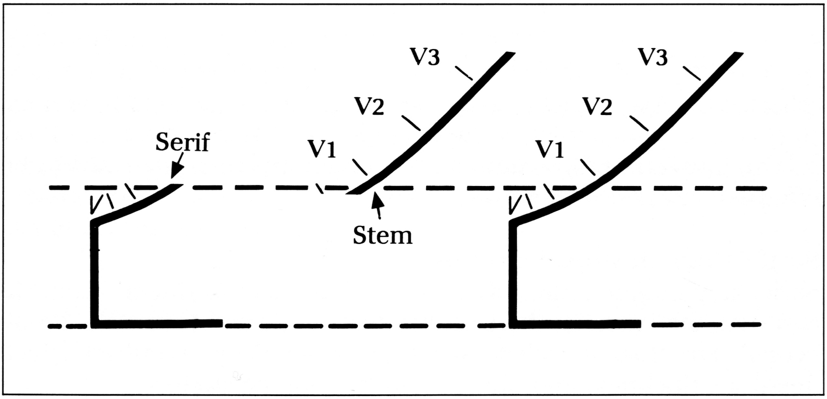
As can be seen in this example, it is imperative that the serifs to be fitted are marked with tangent points.

Serif fitting on sloped strokes

Serifs may be fitted not only to vertical but also to sloped stems. In this case the curve of the serif has to be adjusted to match the diagonal. For this, so-called "alignment points" are required which detail the thickness and direction of the sloping stems.



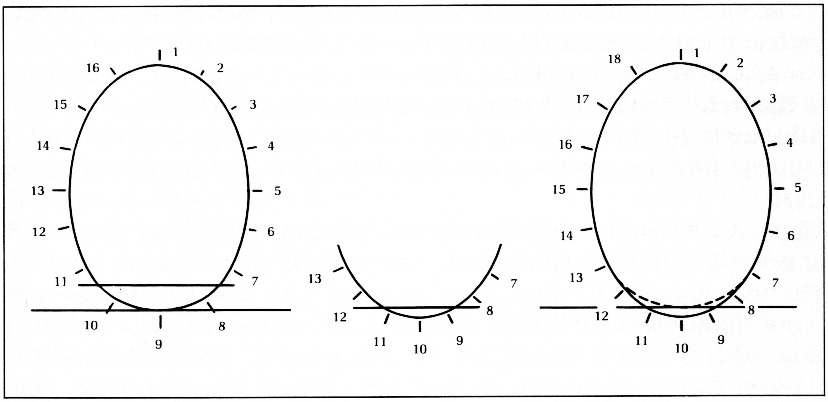
All points in this example also serve as alignment points. In the case of fitting onto straight sloping stems, two alignment points would be sufficient for the program.
When the alignment points are curve points then round fitting is executed.
Three alignment points will always be required to determine and describe a circle.
The last point of the serif part is placed on the circle at its correct Y height. Finally the alignment point which is nearest to the serif is deleted.



5. Post digitizing

If one only has to execute slight corrections to letters, it is possible to post digitize segments rather than carry out a complete new digitization. In order to match the digitizations to the old character, the character number is entered and the left and right side bearings should also be digitized to act as calibration points. The first and last point of the newly recorded part are fitted to the character. A tolerance circle at the start and end points of the post digitization allows automatic fitting of the respective points to the corrected digitization.

First and last points of the post digitization are deleted. Closed lines can also be similarly fitted. A tolerance circle around the start point allows the appropriate closed line to be found.



The number and types of points digitized in the old and new parts do not have to correspond with one another. The number of points is recalculated.

Appendix Z
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The author:
I was born a farmer's son in Stargard, Pomerania, on the 11th of November 1940, but in 1945 the family fled as refugees to the vicinity of Hamburg. From school I progressed to university, where I studied high energy physics leading to a dissertation in 1971 concerning meson production through electrons.
My partners Rubow and Weber founded URW (Unternehmensberatung Rubow Weber) in the same year, and I joined them as a third partner early in 1972. Later that year I met with Walter Brendel of Düsseldorf and the company ARISTO in Hamburg as consultant programmer to develop a method of cutting typeface rubyliths with a flatbed plotter.
Had I been told at the time that digital type would become the work of a lifetime, I would never have believed it. This work swiftly became, however, a most enjoyable and exciting task continuing to the present day, full of meetings with the pleasant and interesting people in our little typographic world (maybe only 1000 people on the whole planet), many of whom are friends or members of the ATYPI.
Initially, due to bugs, IKARUS as a program often "fell to earth" as Greek mythology taught us long ago. For the help and support received during each crisis from my two partners Rubow and Weber, help which has continued unchanged throughout the years, I remain very grateful indead.
I am also very grateful to Hermann Zapf for good advice, for introducing me to ATYPI in 1975, and for wholeheartedly supporting our digital approach to type.
Concerning further developments, we, the URW partners, together with Hermann Zapf, have formed a new company this year called URW Master Design GmbH, to design and program so called masters (a little bit more than canned templates) to lend the special qualities of typography to the many varied kinds of text documents presently in use.

Peter Karow

Production
Cover: Calligraphy by Jovica Veljovic
Translation: Mike Daines, Dietrich Buglass
Correction: Andy Newton
Layout: Christine Utech
Text setting: Renate Gloor

Typeface
Name: Marconi roman demi italic
Typesetter: Digiset 200T1, HELL Gmbh, Kiel

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